BBC

PREVIOUSLY **BBC FOCUS** MAGAZINE

Science Focus

Past, with flying colours

The lab cooking up
ALIEN ATMOSPHERES ON EARTH

Can rewilding
FIX CLIMATE CHANGE?

The fight against
SLEEPING BEAUTY SYNDROME

TECHNICOLOUR DINOSAURS

The new discoveries shedding light on their mysterious lives

SF
SCIENCEFOCUS.COM
£4.99 #337
JULY 2019

IN THIS ISSUE

CATCH THE SUMMER LIGHT
WITH NIKON

INSTANT
SAVINGS

Photographer: Alina Rudya

SAVE **TODAY**

CAPTURE TOMORROW

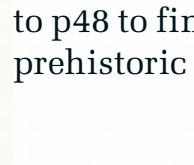
Get instant discounts on selected Nikon cameras and NIKKOR lenses.
Save today! Offer available from **15th May 2019 until 15th August 2019**.
For details on the range of products available and T&C please visit **nikonpromotions.co.uk**
Available at participating retailers.

Nikon

FROM THE EDITOR

There's never been a better time to be a dino hunter. As new dig sites open up around the world, scientists are virtually tripping over near-pristine fossils, identifying totally new species every week. And with each discovery, the past vision of scaly beasts lumbering across vast plains has started to come into sharper focus, revealing a vibrant world populated by the kind of rich biodiversity we see in the wildest places on Earth today.

In particular, we're really starting to understand what these creatures looked like. It's a crucial part of the picture, since we know that an animal's appearance is usually a response to the world around it: some species find success in camouflage, while others find flamboyance more useful. So as we start to resolve the finer details of the colours and patterns of dinosaurs, we also start to see the world in which they lived. And as it turns out, that world may have been an even more ferocious place than we once thought. Head to p48 to find out how scientists are looking back in time at our prehistoric planet.



Daniel Bennett, Editor

WANT MORE? FOLLOW **SCIENCEFOCUS** ON FACEBOOK TWITTER PINTEREST INSTAGRAM

ON THE BBC THIS MONTH...

Radio
How are we evolving? Can household microbes hurt us? Could dark matter harbour dark life? Tune in to *Crowd Science* on the BBC World Service to find out what the team will answer next. **bit.ly/crowd_science**

BBC Sounds
Don't miss Kevin Fong's brilliant podcast, *13 Minutes To The Moon*, with score from Hans Zimmer (!), in the run up to the Apollo anniversary. **bbc.co.uk/sounds**

iPlayer
The showstopping *Earth From Space* uses cutting-edge satellite and drone tech to give you a unique perspective of the Earth, including a seal colony in Siberia. **bit.ly/earth_from_space**

COVER: MAGIC TORCH THIS PAGE: SHUTTERSTOCK, GETTY IMAGES, BBC

Why do some people doodle? → p86

CONTRIBUTORS

PHILIP BALL
Could exoplanet atmospheres reveal hints of distant life? Science writer Philip looks at the research that's recreating this alien air on Earth. → p72

DR JULES MONTAGUE
Kleine Levin Syndrome is a little understood disorder where people sleep for up to 20 hours a day for weeks on end. Neurologist and writer Jules investigates. → p66

DR SALEYHA AHSAN
CBD oil is the latest health craze to sweep the nation, but is there any science to back up its claims? *Trust Me, I'm A Doctor* presenter Saleyha takes a look. → p32

PROF NICK BERESFORD
The huge success of the drama *Chernobyl* has inspired adventurous tourists to visit, but is it safe? Nick has been studying the site for three decades. → p36

CONTACT US

Advertising
neil.lloyd@immediate.co.uk
0117 300 8276
Letters for publication
reply@sciencefocus.com
Editorial enquiries
editorialenquiries@sciencefocus.com
0117 300 8755
Subscriptions
bbcsciencefocus@buysubscriptions.com
03330 162 113*
Other contacts
sciencefocus.com/contact

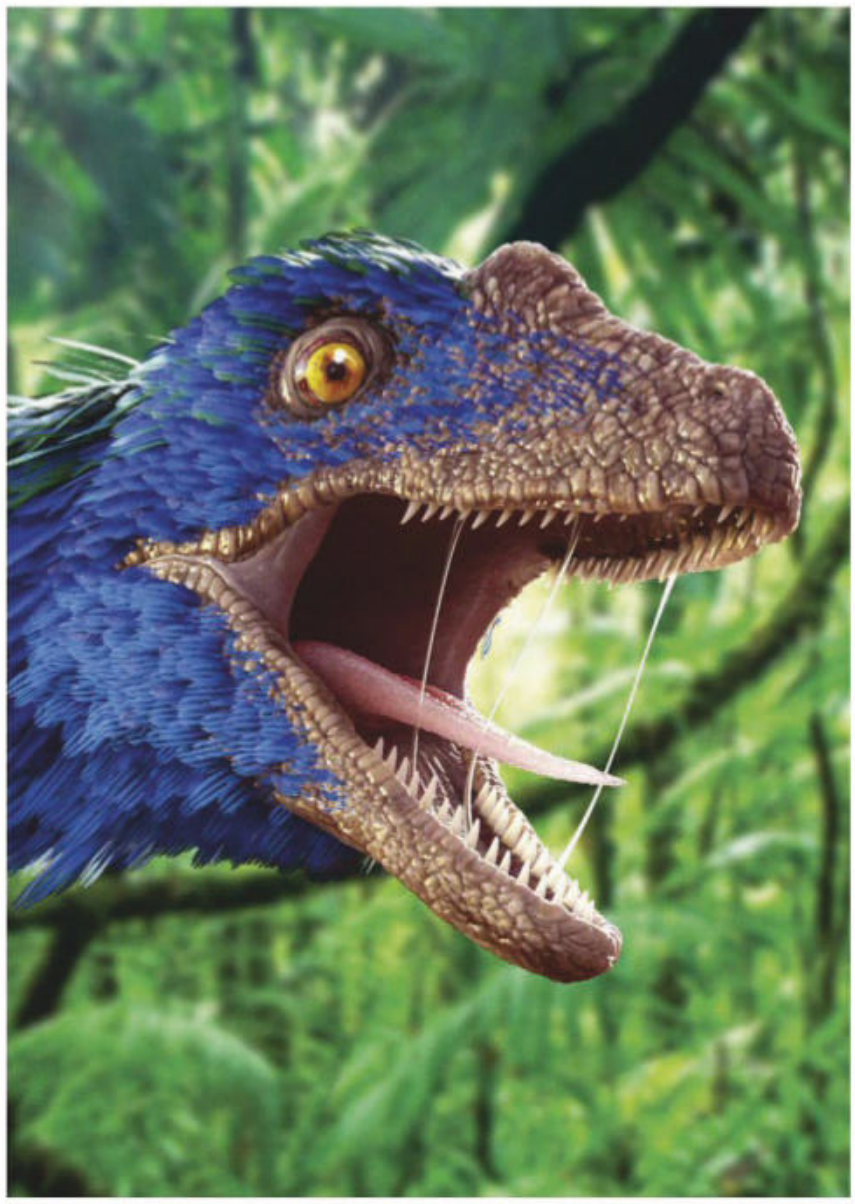
*Calls from landlines will cost up to 9p per minute. Calls from mobile phones will cost between 3p and 55p per minute but are included in free call packages. Lines are open 8am-6pm weekdays and 9am-1pm Saturday for orders only. If calling from overseas, please call +44 1604 973 721. *BBC Science Focus* (ISSN 0966-4270) (USPS 015-160) is published 14 times a year (monthly with a Summer issue in July and a Christmas issue in December) by Immediate Media Company, Bristol, 2nd Floor, Tower House, Fairfax St., Bristol BS1 3BN. Distributed in the US by Circulation Specialists, LLC, 2 Corporate Drive, Suite 945, Shelton, CT 06484-6238. Periodicals postage paid at Shelton, CT and additional mailing offices. POSTMASTER: Send address changes to *BBC Science Focus*, PO Box 37495, Boone, IA 50037-0495.

CONTENTS

REGULARS

FEATURES

48
TECHNICOLOUR DINOSAUR



72
COOKING UP ALIEN ATMOSPHERES

58
TOXIC MASCULINITY

> "As men embrace the things that feminism and gender equality have brought on, we get to be happier, healthier..."

WANT MORE?

Don't forget that *BBC Science Focus* is also available on all major digital platforms. We have versions for Android, Kindle Fire and Kindle e-reader, as well as an iOS app for the iPad and iPhone.

Can't wait until next month to get your fix of science and tech? The Science Focus website is packed with news, articles and Q&As to keep your brain satisfied.
sciencefocus.com

SPECIAL ISSUE

ON SALE NOW

MAN ON THE MOON
Celebrate the golden anniversary of the first Moon landing with this *BBC Science Focus* special edition and retrace the journey from the start of the space race to the moment Neil Armstrong took his historic small step. Plus, experts reveal why we should return to the Moon.
buysubscriptions.com/focuscollection

EYE OPENER

Bugs bunny

AFRICA

With its snub 'nose', fuzzy hair and large eyes, this moth looks decidedly bunny-like. The African death's-head hawkmoth, which has a wingspan of up to 12.7cm, is so-named because of the skull-like pattern on its back, which was made famous by the 1991 film *The Silence Of The Lambs*.

Its compound eyes are made up of as many as 30,000 smaller units (called 'ommatidia'), allowing them to detect rapid movement, while the hairy body is an adaptation for flying at night. "In the insect world, moths are unusually furry – especially the night-flying ones," says entomologist Prof Adam Hart, from the University of Gloucestershire. "The hairs help them to conserve heat – important during cooler nights – and also to disperse bat sonar, making them harder to catch."

HEIDI & HANS JURGEN KOCH

VISIT US FOR MORE AMAZING IMAGES:

SCIENCEFOCUS

BBCSCIENCEFOCUS

EYE OPENER

Plasma dough-nut

GREIFSWALD, GERMANY

Physicist Dr Dorothea Gradic explores the plasma vessel of the Wendelstein 7-X nuclear fusion reactor. Wendelstein 7-X is the world's largest stellarator, an experimental design of fusion reactor. The plasma is blisteringly hot and low density: the 30 milligrams of charged particles reach 100,000,000°C in the 30-cubic-metre vessel. The particles are confined to the centre by super-conducting magnetic coils that cause the particles to spin in circles around the doughnut-shaped reactor. In a functioning reactor, the low-mass particles then collide. When two low-mass atomic nuclei combine, the newly formed nucleus has to jettison energy or risk breaking apart. It is this energy which can be converted into electricity.

VOLKER STEGER/MAX PLANCK INSTITUTE

VISIT US FOR MORE AMAZING IMAGES:

SCIENCEFOCUS

BBCSCIENCEFOCUS

CONVERSATION

YOUR OPINIONS ON SCIENCE, TECHNOLOGY AND *BBC SCIENCE FOCUS*

reply@sciencefocus.com
BBC Science Focus, Tower House, Fairfax Street, Bristol, BS1 3BN
@sciencefocus
www.facebook.com/sciencefocus
@bbcsciencefocus

LETTER OF THE MONTH

Language barrier

I would like to register how much I appreciated and valued Angela Saini's insight into the embedded racism in science and other areas of our lives (June, p48). I was taken aback to realise that I too had an ingrained element of racism that I was unconsciously practising in my daily life.

I live in East Anglia where there are thousands of immigrants from eastern European countries and Portugal working in the agricultural and food sectors. By and large, they are indistinguishable from the majority of the population in terms of their looks and behaviour. So how was I able to regularly categorise them as being Polish, Romanian, Latvian, etc. By one thing only: their languages.

The interview helped me realise that I was immediately categorising them as different. If they had a command of English identical to my own, there would be virtually no way I could judge their origin. I like to think (and hope) I'm not racist: I supported Remain in the EU elections, and I feel immigrants who come here to contribute can benefit us all.

The article also raised a question over the immigration issue in respect of Brexit. Would immigration be such a high profile element of the campaign if all immigrants spoke 'perfect' English and were virtually indistinguishable from the rest of the population? It's surely a textbook example of embedded racism within our society, which has little base in logic. If racism occurs due to difficulty communicating, what hope do we have for a tolerant society, let alone a tolerant scientific community?

Roger Lancaster, *via email*

Often an accent is all it takes for us to start making assumptions about people. But being aware of biases in our thinking is a good start to overcoming them.

Daniel Bennett, *Editor*

WRITE IN AND WIN!

The writer of next issue's *Message Of The Month* win this **Yeti Nano** USB microphone from Blue Microphones. It's perfect for gaming, creating content or just chatting to friends online. Its broadcast quality sound and high sensitivity make it ideal for recording, podcasting and performing.

bluedesigns.com/products/yeti-nano/

WORTH £89.99

Two wheels bad

I was a bit disappointed in Daniel Bennett's response to the letter from M Manley regarding irresponsible cyclists (June, p10), where he seems to imply that he would rather see more irresponsible cyclists on the roads than drivers.

I appreciate that this is based on the damage caused by a vehicle accident, but I would like to point out that (apart from stolen vehicles, obviously) all drivers are traceable, whereas cyclists are not. The sooner there are national registration and licensing schemes for cyclists and their bikes the better. The argument trotted out against this is that it would put people off cycling, but I have yet to hear of anyone being put off having a car because of the need to register it and have a driving licence.

Peter Cole

That's a fair point. But one of the tools that licence and registration schemes provide is a means to trace 'hit and run' drivers who leave the scene of an accident. Cyclists involved in accidents with motor vehicles are rarely able to leave the scene since they often end up injured, in need of medical attention and without a functioning means of transport.

Daniel Bennett, *Editor*

Money problems

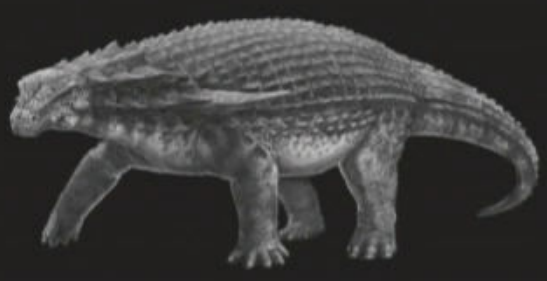
In 2017, UK bank customers lost £236m to fraudsters pretending to be phoning from their bank. Usually the banks say they cannot get the money back once it's been transferred, so the customer loses their money and the fraudsters can't be traced or prosecuted. But why can't the money being electronically transferred be given an electronic serial number, similar to that found on real money? Your recent feature on deepfakes (June, p46) mentioned 'sonic watermarks' being embedded in audio files belonging to the

company Modulate to trace their work and prevent its misuse.

How much more useful it would it be if money being transferred had an 'electronic serial number'? Something that required validation before the money could be received or spent. This way, any money stolen could simply be declared counterfeit by the Bank of England and of no value to the thieves.

This would render this type of fraud ineffective at a stroke, no matter where in the world the money was sent. It might also be helpful in ensuring tax is paid on 'dirty money'.

Barry Cash, *via email*



"THERE WERE SOME SCARY PREDATORS AROUND. EVEN IF YOU WERE ARMOURED TO YOUR TEETH, YOU WERE NOT SAFE"

DR JAKOB VINTHER, p48

Military man

In your profile of the Leonardo da Vinci exhibition (June, p90) there is the oft repeated assertion that da Vinci did little or no practical work. He did, however, do considerable amounts of work on military architecture. His most notable patron was Cesare Borgia, a man who notoriously insisted on results. There is good reason to suppose that da Vinci's wealthy patrons protected him from the Inquisition, who would not have approved of his lifestyle or his anatomical experiments.

Paul Jeffels Derby, *via email*

Military commander Cesare Borgia was one of Leonardo da Vinci's patrons

ALAMY, GETTY IMAGES

Revisiting revision

Regarding the article on exam revision (May, p98), I was surprised to see a few of my favourite revision methods downplayed, particularly multitasking. When I first started doodling or crocheting during lectures and revision, I found my capacity to take in what I was learning increased massively and my exam scores went up! I guess we all learn and revise differently.

Debbie, *via email*

Computer class

With regard to the article titled *The Benefits Of Video Games: Why Screen Time Isn't Always Bad* (March, p36), I'd like to add the benefits of learning through gamification. As a lecturer I find screen time useful and essential in today's reality where interactions occur virtually. Games such as *Kahoot!* turn a classroom into a challenging virtual game where students interact, compete and learn. At the same time they are assessed, providing a win win situation for the students and the educator.

We're at a turning point in education where we need to embrace video games that hold the interest of the younger generation, and use them as a tool to enhance learning by getting the student active and keeping them engaged.

Cassandra Sturgeon, *via email*

"WE'RE AT A TURNING POINT IN EDUCATION WHERE WE NEED TO EMBRACE VIDEO GAMES"

Oops...

In *Rethinking Dementia* (May, p66) we mistakenly referred to the University of Worcester doctoral researcher compiling music playlists for dementia sufferers as Ruby Smith. Her name is, in fact, Ruby Swift.

THE TEAM

EDITORIAL
Editor Daniel Bennett
Production editor Alice Lipscombe Southwell
Commissioning editor Jason Goodyer
Online editor Alexander McNamara
Staff writer James Lloyd
Editorial assistant Helen Glenny
Online assistant Sara Rigby
Science consultant Robert Matthews

ART
Art editor Joe Eden
Deputy art editor Steve Boswell
Picture editor James Cutmore

CONTRIBUTORS
Acute Graphics, Philip Ball, Rob Banino, Hayley Bennett, Peter Bentley, Dan Bright, Verity Burns, Charlotte Corney, Emma Davies, Alexandra Franklin Cheung, Juanjo Gasull, Alice Gregory, Hilary Guite, Alastair Gunn, Jules Howard, Tara Jacoby, Christian Jarrett, Aleks Krotoski, Penny Lewis, Magic Torch, Jules Montague, Michael Mosley, John Pickrell, Helen Pilcher, Emmanuel Polanco, Dean Purnell, Helen Scales, Ori Toor, Maxim Usik, Luis Villazon, Bob Wilson.

ADVERTISING & MARKETING
Group advertising manager Tom Drew
Advertising manager Neil Lloyd
Senior sales executive Anastasia Jones
Brand sales executive Sarah Smith
Brand sales executive Hannah Rich
Newstrade manager Helen Seymour
Subscriptions director Jacky Perales Morris
Direct marketing manager Kellie Lane

MOBILE
Head of apps and digital edition marketing Mark Summerton

INSERTS
Laurence Robertson 00353 876 902208

LICENSING & SYNDICATION
Director of licensing and syndication Tim Hudson
International partners manager Anna Brown

PRODUCTION
Production director Sarah Powell
Production coordinator Lily Owens Crossman
Ad services manager Paul Thornton
Ad coordinator Jade O'Halloran
Ad designer Julia Young

PUBLISHING
Commercial director Jemima Dixon
Content director Dave Musgrove
Managing director Andy Healy
Group managing director Andy Marshall
CEO Tom Bureau

BBC STUDIOS, UK PUBLISHING
Director of editorial governance Nicholas Brett
Director of consumer products and publishing Andrew Moultrie
Head of publishing Mandy Thwaites
UK publishing coordinator Eva Abramik
Contact UK.Publishing@bbc.com
www.bbcstudios.com

EDITORIAL COMPLAINTS
editorialcomplaints@immediate.co.uk

ANNUAL SUBSCRIPTION RATES (INC P&P):
UK/BFPO £63; Europe & Eire Airmail £66; Rest of World Airmail £70.

ipso. Regulated

abc Audit Bureau of Circulations
50,022 (combined; Jan-Dec 2018)

IMMEDIATE MEDIA Co

BBC Science Focus Magazine is published by Immediate Media Company London Limited under licence from BBC Studios who help fund new BBC programmes.

TORO

THE BRAND **PROFESSIONALS TRUST**

From Manchester United and Real Madrid football clubs to St Andrews Links, professionals count on Toro to deliver exceptional quality and results.

POWERFUL IN **BOTH DIRECTIONS**

Every garden has that tough spot. One that gives you a hard time every time you mow. The playground set, fence corners, or rolling hills. Are you tired of putting your body through its paces? Take charge with the PoweReverse®, the easiest way to mow with power assist in both directions.

Learn more about the PoweReverse® at TORO.COM/FocusMagazine or call 0800 781 1655 to request a brochure

POWEREVERSE®
55 cm MOWER

DISCOVERIES

Bioprinted organs one step closer

Synthetic organs suitable for transplant could be ready in as little as two decades

This stunning image shows a 3D-printed model of a lung-mimicking air sac complete with functioning airways that are capable of delivering oxygen to surrounding blood vessels. It was made by a team of researchers in the US by gradually building up layers of hydrogel, a synthetic, jelly-like material that shares many features with human tissue.

The same technique could be used for creating complex, entangled vascular networks that mimic the body's natural passageways for blood and other vital fluids, potentially opening up a new means of bioprinting human organs for transplant, the researchers say.

The work was led by Rice University's Jordan Miller and the University of Washington's Kelly Stevens, along with collaborators from Duke University, Rowan University, and Nervous System, a design firm in Somerville, Massachusetts.

JORDAN MILLER/RICE UNIVERSITY

News in brief

WASABI-RESISTANT MOLE RATS COULD HELP US MAKE BETTER PAINKILLERS

Highveld mole rats – small rodents found in Africa – are immune to the eye-watering sting of wasabi, researchers at the University of Illinois have found. The discovery could lead to new approaches for treating pain in humans. The team tested allyl isothiocyanate, the compound that gives wasabi its hit, on eight species of mole rats. The Highveld rodents were the only ones to remain unaffected.

Dubbed 'Stereolithography Apparatus for Tissue Engineering', or SLATE, Miller and Stevens's technique works by building up layers of a liquid pre-hydrogel solution that become solid when exposed to blue light. It can produce soft, 3D structures made from water-based, biocompatible gels with intricate internal architecture in minutes.

In tests, the resulting air sac was sturdy enough to avoid bursting as blood flowed through it and took in and expelled air that simulated the pressures and frequencies of human breathing. It was also found that red blood cells could take up oxygen as they flowed through a network of blood vessels surrounding the 'breathing' air sac – a process similar to the gas exchange that occurs in the lung's air sacs.

"One of the biggest road blocks to generating functional tissue replacements has been our inability to print the complex vasculature that can supply nutrients to densely populated tissues," said Miller. "Further, our organs actually contain independent vascular networks – like the airways and blood vessels of the lung or the bile ducts and blood vessels in the liver. These interpenetrating networks are physically and biochemically entangled, and the architecture is intimately related to tissue function."

The researchers are already using the new technique to explore more complex structures and have successfully transplanted 3D-printed tissues loaded with primary liver cells into mice with chronic liver injury.

"The liver is especially interesting because it performs 500 functions – second only to the brain," Stevens said. "The liver's complexity means there is currently no machine or therapy that can replace all its functions when it fails. Bioprinted human organs might someday supply that therapy."

There are currently around 6,000 people waiting for organ transplants in the UK alone. Bioprinted organs could not only help meet this need but, as they can be printed using a patient's own cells, they could also greatly reduce the possibility of organ rejection. "We envision bioprinting becoming a major component of medicine within the next two decades," Miller said.

For the latest science news, visit ***sciencefocus.com***

Bagrat Grigoryan, a bioengineer at Rice University, oversaw the development of a 3D printing technique that's capable of building functioning vascular structures

HUMAN COMPOSTING LEGALISED IN US

Washington has become the first US state to legalise human composting. The process works in much the same way as regular composting, with a person's body being placed into a container and left to decompose. It will be offered as a natural alternative to traditional burials.

"Why don't you go out and find yourself a nice girlfriend, son? That'll cheer me... ahem, you up, I'm sure"

JORDAN MILLER/RICE UNIVERSITY, GETTY IMAGES, MARTIN SURBECK ILLUSTRATION: TARA JACOBY

PRIMATOLOGY

Bonobo mums drag their sons to ovulating females

Helicopter parenting is not a uniquely human trait, it seems. Female bonobos interfere with their sons' love lives in order to get grandchildren, a new study has found.

Scientists observed bonobos in the Democratic Republic of the Congo – the only country where these great apes are found in the wild. The ape mums engaged in a variety of behaviours to increase their chances of having grandchildren, including protecting their sons' mating attempts from interfering rivals, intervening in rivals' mating attempts and dragging their sons to ovulating females. The overbearing mums' tactics proved successful, as their sons were three times more likely to have children.

"This is the first time that we can show the impact of the mother's presence on a very important male fitness trait – their fertility," said Dr Martin Surbeck, a primatologist at the Max Planck Institute for Evolutionary Anthropology, who led the study. "We were surprised to see that the mothers have such a strong, direct influence on the number of grandchildren they get."

Uniquely among the great apes, bonobos live in what some primatologists believe is a matriarchal society, with males deriving their status from the status of their mum. Like a VIP pass to high society, the bonobo mums were seen using their status to give their sons access to popular spots in the community, helping the males to achieve better status and better mating opportunities.

Why the mums are so keen to have grandchildren is not clear, but Surbeck and his team think that the behaviour could have evolved as a way for bonobos to propagate their genes, albeit indirectly. "These females have found a way to increase their reproductive success without having more offspring themselves," said Surbeck.

They did what?

Electronic tongue designed to taste spicy food

WHAT DID THEY DO?

Researchers at Washington State University created an e-tongue lined with sensors to detect spicy, sweet, salty, sour and umami flavours, and then 'fed' it cheese of varying degrees of spiciness.

WHAT DID THEY FIND?

Effectively tasting spicy food can be a problem, even for those of us who regularly snarf down a vindaloo on a Friday night, as human taste buds are quickly overloaded by capsaicin – the compound that gives curries their kick. By contrast, the e-tongue can be used over and over again without succumbing to the numbing effect of spice. It's also better at determining the difference between two very mild spices or two very hot ones than a human tongue.

WHY DID THEY DO THAT?

The e-tongue could potentially be used in the food industry to speed up taste testing by quickly narrowing down the desired flavour profiles of foods before turning the dishes over to humans for final testing, the researchers say.

SEXUAL ORIENTATION CHANGES WELL INTO ADULTHOOD

Research has confirmed that sexuality remains fluid past adolescence. Analysis of surveys of around 12,000 American students showed that changes in attraction, sexual partners and identity are common throughout the 20s. Dr Christine Kaestle at Virginia Tech, who led the research, suggests new categories, expanding on traditional labels of 'gay', 'bisexual' and 'straight'. For instance, 'emerging gay' and 'emerging bi' can describe those who have mostly heterosexual sex in their teens but develop stronger same-sex or both-sex attractions in their 20s. Overall, male participants were more likely to be straight, and females had a more fluid sexuality over time.

Trending

YOUR GUIDE TO WHO'S SAYING WHAT ABOUT THE HOTTEST TOPICS IN THE WORLD RIGHT NOW

#MurrayGell-Mann

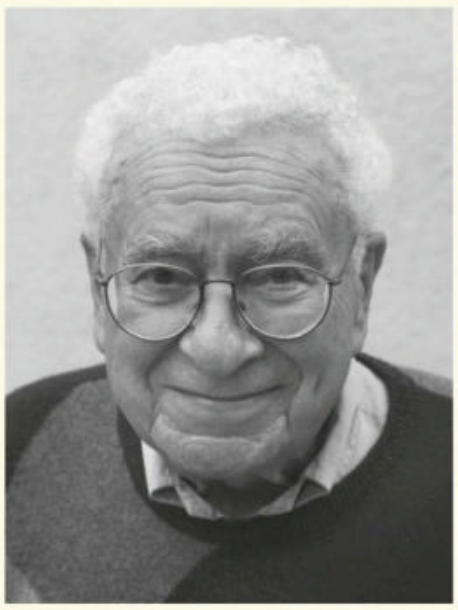
Murray Gell-Mann (below), the Nobel Prize-winning physicist who identified quarks – the subatomic particles that make up protons and neutrons – has died aged 89.

Jim Al-Khalili
@jimalkhalili

Just heard that the physicist who gave us the 'quark', Murray Gell-Mann, died yesterday, aged 89. He was one of the greatest scientists of the 20th Century and won the Nobel Prize 50 years ago for classifying the building blocks of matter.

Somak Raychaudhury
@somakrc

Here goes the only physicist who picked the name of his newly postulated particle from the most difficult novel of James Joyce. Such polymaths are rare, and are getting rarer. Peace #MurrayGellMann



#LundyIsland

The seabird population on Devon's Lundy Island has tripled in the last 15 years following a successful project to eradicate predatory rats on the island.

Tony Juniper
@TonyJuniper

Delighted today @NaturalEngland to be reminded that we can actually bend back the curve of Nature's decline. News of seabird recovery on Lundy Island via work with @Natures_Voice @nationaltrust & others shows us what is possible with planning & partnership.

RSPB South West
@RSPBSouthWest

Fantastic news – Seabirds flock back to Lundy Island. New RSPB study has revealed that total seabird numbers on Lundy have now tripled to over 21,000 birds, & key species like Manx shearwater have increased to more than 5,500 pairs, & puffins to 375 birds.

#ChineseMedicine

The World Health Organization has officially recognised the use of traditional Chinese medicine for the treatment of 400 medical conditions in its recently published International Classification of Disease list.

Stephen MacMahon
@macmahonstephen

Chinese medicine to gain WHO acceptance despite the virtual absence of data on efficacy or safety. A dangerous precedent has been set.

Dr. Jonathan Kolby
@MyFrogCroaked

This is concerning because many types of #wildlife used in Traditional Chinese Medicine are critically endangered, such as #tigers, #rhinos, and #pangolin @extinctsymbol @CITES @who

KEEP IN TOUCH

@SCIENCEFOCUS

#Measles

Measles outbreaks have been reported in three London schools – Fulham Boys School, Chelsea Academy and St Marylebone Church of England School. Public Health England is now calling for all parents to ensure their children get the MMR vaccine when offered or to get it now if they missed it at the scheduled time.

Alexandra Olaya-Castro
@AlexOlayaCastro

Measles outbreak in some of the wealthiest boroughs in London. Notice nearly half a million UK kids missed out their MMR vaccination in the last 8 years. The main reason is misinformation about vaccine safety. Is it time to make vaccines mandatory?

Danny Chambers
@DannyVet

Significant measles outbreak reported at a number of London schools. This is due to the reduced uptake of the measles vaccination. The WHO has included vaccine hesitancy as one of the most serious global public health concerns of 2019 #vaccines

GETTY IMAGES X5, YANIV BERMAN/ISRAEL ANTIQUITIES AUTHORITY

ABOVE: **Yeast obtained from ancient pots like this one allowed scientists to recreate bygone beers**

MICROBIOLOGY

Unbeerlievable: Ancient Egyptian ale recreated from 5,000-year-old yeast

This really raises the bar: scientists have resurrected beer from yeast found in antique pottery, giving a taste of life in Ancient Egypt. Beer was a staple part of the diet back then, and was a safer alternative to water. It also played an important role in religious ceremonies.

In a bid to find ancient yeast, Israeli researchers examined shards of jugs, believed to have contained either beer or mead, found at two Egyptian sites in the Holy Land, as well as sites associated with the Philistines and Persians.

Six different strains of yeast were isolated from the pottery. Incredibly, the yeast had survived for up to 5,000 years inside the ceramics' microscopic pores.

When the researchers sequenced the genomes of the yeast strains, they found similarities with the yeasts used in traditional African brews, such as the still-popular Ethiopian honey wine 'tej', and also those used in modern beer.

When it came to recreating the bygone beer, three of the yeast strains were particularly successful, producing an "aromatic and flavourful" drink with 6 per cent alcohol content.

"By the way, the beer isn't bad"

"The greatest wonder here is that the yeast colonies survived within the vessel for thousands of years, just waiting to be excavated and grown," said Dr Ronen Hazan, a microbiologist at the Hebrew University of Jerusalem who was co-leader of the study. "This ancient yeast allowed us to create beer that lets us know what ancient Philistine and Egyptian beer tasted like. By the way, the beer isn't bad."

The researchers say that their techniques aren't limited to yeast, and could be used to detect the ancient bacteria used in the production of foods such as cheese and pickles. Pharaoh fondue, anyone?

COFFEE DRINKERS
For many of us, starting the day without a coffee would be unthinkable. Now, a study carried out at Monash University in Australia has found that merely *thinking* about a cup of joe can perk up the mind of coffee drinkers. The same effect was not seen in tea lovers.

GARDEN BIRDS
Thanks to more of us putting out fat balls and feeders, the number of species of birds found in UK gardens is growing, a study by the British Trust for Ornithology has found. Regular visitors include goldfinches, woodpigeons and long-tailed tits.

Good month

Bad month

SLOW WALKERS
Brisk walkers live longer than slowpokes, according to a study of nearly 500,000 people carried out by research body UK Biobank. These findings could clarify the importance of maintaining fitness and a healthy weight.

MEDITATORS
A study carried out at UCL has revealed that there could be a dark side to meditating. In an international survey of more than 1,200 regular meditators, the researchers found that more than a quarter have had a 'particularly unpleasant' psychological experience related to the practice, including feelings of fear and distorted emotions.

TODDLERS PICK UP WORDS MORE QUICKLY FROM OTHER KIDS
Little 'uns pick up new words best from other children, a study at Purdue University, Indiana, has found. Previous research has shown that children learn speech patterns from their family. But this study suggested that toddlers learn new words best from other kids, and picked up most words from children who were between 8 and 10 years old.

FOOD

Want to save the planet? Eat maggot sausages

This gives a whole new meaning to the term 'grub'. Thanks to a growing worldwide demand for meat, we may soon have to turn to alternative sources of protein, such as sausages made from mashed-up maggots, researchers at the University of Queensland claim.

> "One of my students has created a very tasty insect ice cream"

Around 200 years ago there were fewer than a billion humans living on Earth. According to UN calculations there are now more than seven billion of us, with current studies predicting that this figure will top 10 billion by 2050. This is likely to put a strain on global food supplies, so the team at Queensland has been investigating the possibility of incorporating alternative protein into our diets using insects.

"An overpopulated world is going to struggle to find enough protein unless people are willing to open their minds, and stomachs, to a much broader notion of food," said meat scientist Prof Louwrens Hoffman. "The biggest potential for sustainable protein production lies with insects and new plant sources."

Though many cultures across the world do currently consume insect protein, previous studies have shown that Western consumers are only willing to try such foods if the ingredients are processed and disguised. "Insect protein needs to be incorporated into existing food products as an ingredient. For example, one of my students has created a very tasty insect ice cream," he said.

Prof Louwrens Hoffman: "Maggots for you, beef fillet for me"

ENTOMOLOGY

Royal jelly vaccines may help stop honey bee decline

Royal jelly, a creamy substance produced by worker bees to provide food for queen larvae, can spread immunity between honey bees, according to a new study. This effect could be harnessed to provide disease protection to honey bee populations. Honey bees are responsible for pollinating large numbers of plants and crops, so it's vital that their populations are maintained.

The researchers, led by Dr Eyal Maori at the Wellcome Trust/Cancer Research UK Gurdon Institute at the University of Cambridge, created 'vaccines' using a biological molecule called RNA. RNA has many roles, and some viruses use RNA in place of DNA. The team fed fragments of virus RNA to honey bees and found that the bees developed a resistance to the virus – just as humans become immune to the sample of disease in a vaccine. The scientists found that this immunity spread around the hive, and was retained in later generations. The RNA fed to the bees entered their circulatory system, where it diffused into their jelly-secreting glands. The jelly the bees produced was then infused with the RNA molecules, and the larvae that fed on this jelly received the disease protection. "We found that RNA spreads beyond individual honey bees, being transferred not just between parents and their progeny, but also among individuals in the hive," said Maori.

The researchers hope that this method could be used to protect honey bees against viruses and the *Varroa destructor* mite, a parasite which has played a significant role in honey bee population decline.

Parasites, habitat loss, intensive agricultural processes and climate change are leaving honey bees in a sticky situation

GETTY IMAGES X2, UNIVERSITY OF QUEENSLAND ILLUSTRATIONS: TARA JACOBY

In numbers

1 IN 7

The number of babies that are born weighing less than 2.5kg (5lbs 8oz) worldwide, as calculated by a study funded by the Bill and Melinda Gates Foundation. The average newborn weight is 3.4kg (7lb 8oz).

10,927m

The depth at which a plastic bag was found by the American explorer Victor Vescovo in April this year when exploring the Pacific Ocean's Mariana Trench. That's the deepest that plastic has been found to date.

$110tn

The global spending on renewable energy sources needed by 2050 to meet climate goals, as estimated by the International Renewable Energy Agency.

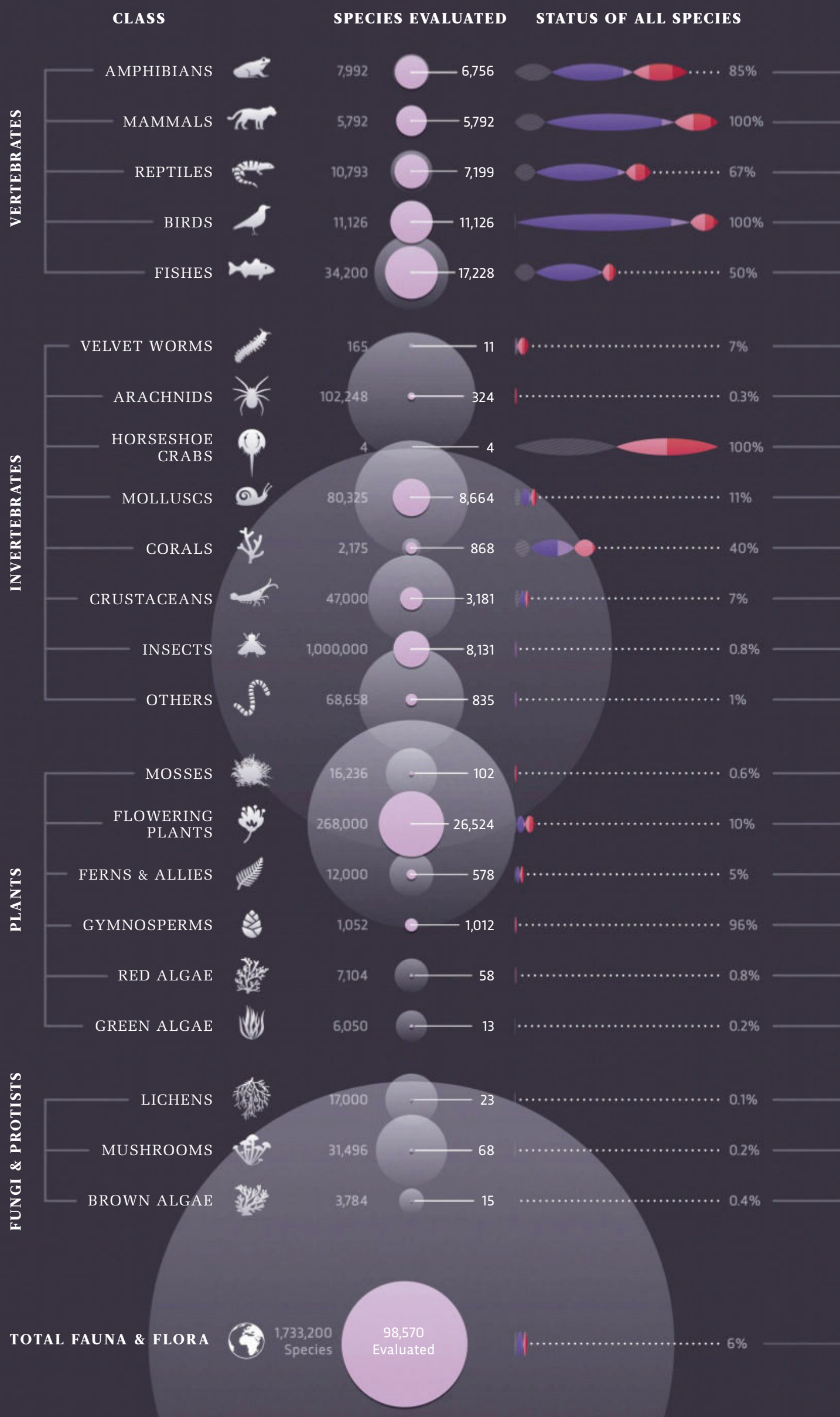
Data crunch

Species under threat

The IUCN Red List visualised

DATA VISUALISATION: SET RESET

According to a recent report commissioned by the UN, nature is declining at rates unprecedented in human history, with the rates of species extinction accelerating at an alarming pace. Some scientists estimate that dozens of species are lost every day. Changes in land and sea use, direct exploitation of organisms, human-made climate change, pollution and the introduction of invasive alien species are all contributing factors.

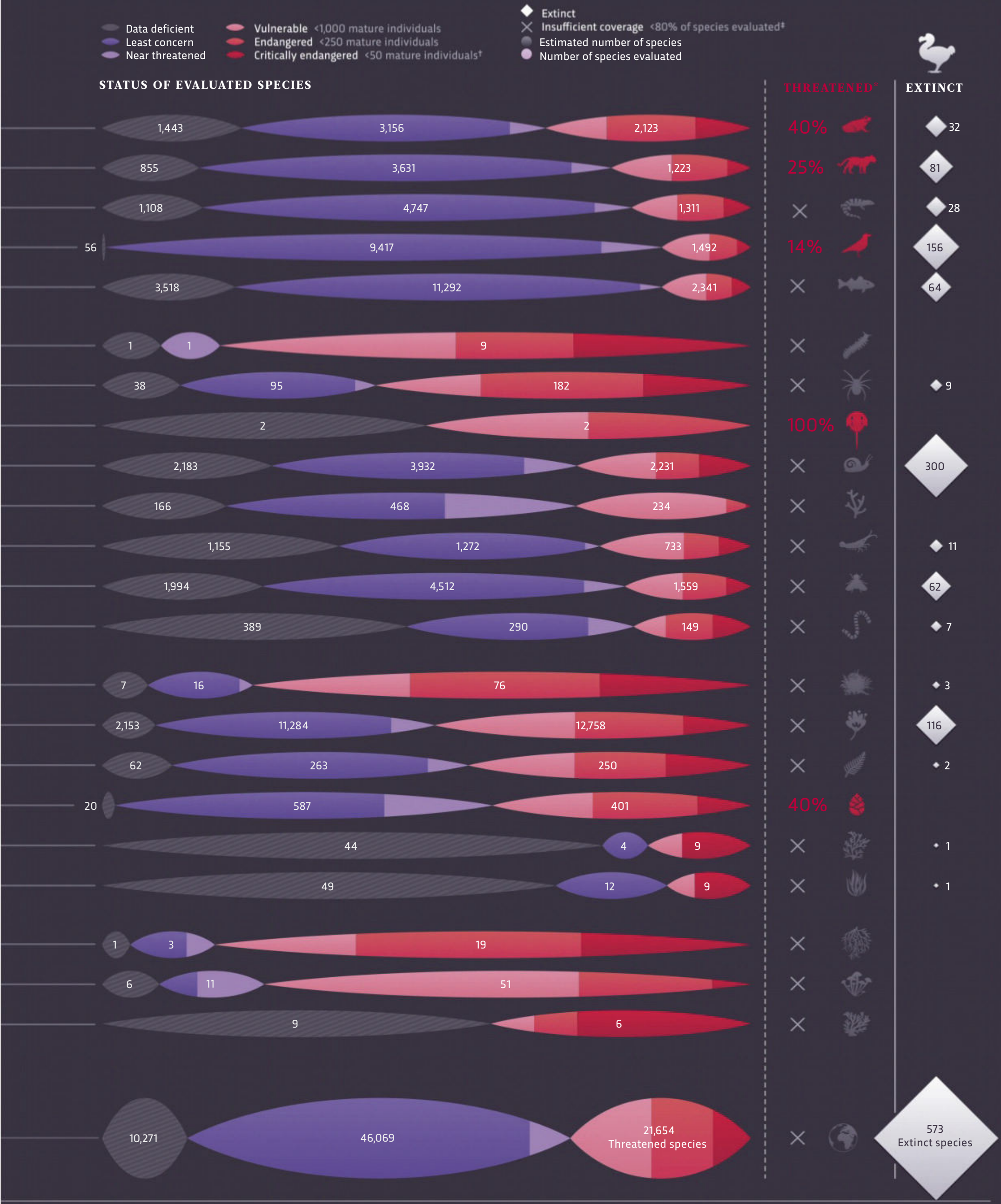


Data source: **IUCN Red List**, Last Updated: 21 March 2019

* Best estimate of species threatened assumes data deficient species are equally threatened as data sufficient species.

† Category definitions for Vulnerable, Endangered and Critically endangered may take other factors into account

‡ Where <80% of species within a group have been evaluated, figures for % threatened species are not provided because there is insufficient coverage for these groups.


Data deficient
Least concern
Near threatened
Vulnerable <1,000 mature individuals
Endangered <250 mature individuals
Critically endangered <50 mature individuals†
Extinct
Insufficient coverage <80% of species evaluated‡
Estimated number of species
Number of species evaluated
STATUS OF EVALUATED SPECIES
THREATENED*
EXTINCT
1,443 3,156 2,123 40% 32
855 3,631 1,223 25% 81
1,108 4,747 1,311 28
56 9,417 1,492 14% 156
3,518 11,292 2,341 64
1 1 9
38 95 182 9
2 2 100%
2,183 3,932 2,231 300
166 468 234
1,155 1,272 733 11
1,994 4,512 1,559 62
389 290 149 7
7 16 76 3
2,153 11,284 12,758 116
62 263 250 2
20 587 401 40%
44 4 9 1
49 12 9 1
1 3 19
6 11 51
9 6
10,271 46,069 21,654 Threatened species
573 Extinct species

Primer

SpaceX Starlink

SPACEX'S AMBITIOUS PROJECT TO PROVIDE BROADBAND CONNECTIONS TO HARD-TO-REACH AREAS OF THE PLANET HAS GOT SOME COMMENTATORS WORRIED ABOUT LIGHT POLLUTION, SPACE JUNK AND THE FUTURE OF ASTRONOMY

WHAT IS IT?

SpaceX's Starlink aims to bring ultrafast broadband internet to the entire planet via a vast constellation of low orbit satellites. The basic idea is that the network will send messages via a series of ground-based terminals. SpaceX's CEO Elon Musk describes the terminals as being 'as big as a pizza box' and can theoretically be installed anywhere, transmitting signals to the satellites using radio waves. The satellites will then beam the message around the planet using lasers until it reaches the desired destination, it will then be beamed back down to Earth via radio waves again.

WHY ARE THEY DOING THAT?

Aside from the purely altruistic goal of providing the entire planet with a reliable, affordable internet connection, Musk has previously stated that the considerable revenue he hopes to generate from the project – somewhere in the region of $3bn a year – could be used to fund SpaceX's even more ambitious goals of establishing human colonies in space. "We think this is a key stepping stone on the way towards establishing a self-sustaining city on Mars and a base on the Moon," he said.

WHAT HAS HAPPENED SO FAR?

On 23 May, at 2:30pm Coordinated Universal Time (UTC), SpaceX kicked off the first phase of the project by successfully placing 60 Starlink satellites into low Earth orbit. They were launched from NASA's Kennedy Space Centre in Cape Canaveral, Florida, on board one of SpaceX's reusable Falcon 9 rockets and deployed about one hour later. Each of the satellites weighs around 225kg making them the heaviest payload carried by a SpaceX rocket to date. Musk confirmed via Twitter that all 60 satellites were online shortly afterwards. They were initially deployed at an altitude of 440km with their thrusters eventually carrying them to their final altitude of 550km. That's higher than the International Space Station, which sits at 408km, but much lower than satellites in geostationary orbit, which sit at 35,786km.

SPACEX

> "We think this is a key stepping stone on the way towards establishing a self-sustaining city on Mars and a base on the Moon"

WHAT HAPPENS NEXT?

The company will now begin a series of tests on the satellites' hardware, including their solar arrays and ion thrusters. In the next year Musk says that he would like to see 720 satellites in orbit and even has plans to start offering an internet service within this time frame. The long-term plan is to have several launches a year until there are nearly 12,000 in orbit in the late-2020s.

WHY THE CONTROVERSY?

The first potential issue that has been raised is that there are already something like 5,000 satellites in low Earth orbit, significantly adding to this number could increase the risk of collisions and the possibility of debris falling to Earth. SpaceX says that as the satellites are designed to disintegrate when they re-enter the Earth's atmosphere this shouldn't be a problem.

WILL WE BE ABLE TO SEE THEM FROM EARTH?

It is too soon to say for sure but most estimates seem to suggest that they will only be visible to the naked eye from very dark sites. However, some astronomers have voiced concerns that the satellites will be visible to optical telescopes and that the radio signals from Starlink could potentially interfere with signals being picked up by radio telescopes.

by **JASON GOODYER**
Jason is the commissioning editor at BBC Science Focus.

UNHCR
The UN Refugee Agency

WHEN ANNA HEARD THE MACHINE GUNS AND SCREAMING SHE RAN...

© UNHCR/Oli Cohen

....in the chaos of the attack on her village in South Sudan, 12-year-old Anna lost her parents. She hasn't seen them since. After a perilous journey through a war zone, where she was at risk of abduction and exploitation, and had little food or water, she became desperately weak and ill with fever, headaches and hunger. Eventually, Anna reached UNHCR in Ethiopia. She is now under our protection and safe, but many more lost and orphaned refugee children from countries torn apart by war and disaster urgently need your support.

There are over 170,000 children like Anna from countries like South Sudan, Myanmar, Venezuela and Syria who have arrived at our camps without their parents and are in desperate need of support.

You can help ensure no lost, separated or orphaned child has to face the trauma and fear of being a refugee on their own.

Your gift of £75

provides a Child Rescue Kit containing: emergency nutrition, water, medicine, clothes, shoes, toiletries and a blanket.

Give now at **unhcr.org/child** or call **0800 029 3883**

Yes, I will help show lost and orphaned children they are not alone

Please accept my gift of: ☐ £75 ☐ £150 ☐ £225 **My choice of** £

Please debit my: ☐ Visa ☐ MasterCard ☐ Maestro

Card no. *Maestro only*

Valid from / Expiry date / Issue number *Maestro only*

Signature Date / /

☐ I enclose a cheque or postal order made payable to UNHCR

Title First name

Last name

Address

Postcode

Email

Phone

Please post urgently to: **Freepost UNHCR.** You do not need a stamp.

Please tell us if you are happy to hear about UNHCR's work:

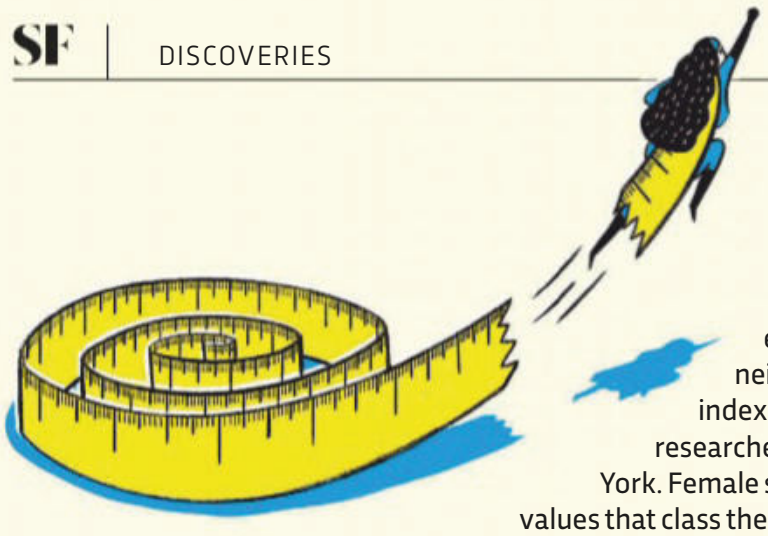
☐ By email ☐ By phone

We will use your details to process your donation and to keep you up to date with our work, fundraising activities and other events. You can read more about how we use your data in our Privacy Policy **www.unhcr.org/uk/privacy-policy**. You can opt out of any communications at any time by emailing supportercare@unhcr.org or by calling 0800 029 3883

BFPAGD19A

Thank you

UNHCR
The UN Refugee Agency



SUPERHEROES HAVE UNHEALTHY BMIS

Comic book characters such as Thor and Black Widow may have exaggerated body shapes, but neither has a healthy body mass index (BMI), according to a new study by researchers at Binghamton University, New York. Female superheroes' usually have BMI values that class them as close to underweight, while their male counterparts' values tend to be classified as obese. The researchers at gathered BMI data for 3,752 Marvel Comics characters and noted their hyper-masculine features (such as higher than average shoulder-to-waist ratios) or hyper-feminine features (including lower than average hip-to-waist ratios).

One of the study's authors, Laura Johnsen, said the characters' forms are exaggerated reflections of the markers that "signal youth, health and fertility in real humans."

PLANETARY SCIENCE

The formation of the Moon brought water to Earth

The cataclysmic collision that created the Moon also brought water to the Earth, allowing life to develop, according to a study by a team of planetologists at the University of Münster, Germany.

The Moon was created 4.4 billion years ago when the Earth collided with a Mars-sized body named Theia. While much of the resulting debris thrown up by the impact coalesced to form our Moon, some of it fell back to Earth and became part of the mantle, the thick rocky layer between the crust and core. The team, led by Dr Gerrit Budde, made the discovery by investigating the composition of the metal molybdenum found in the Earth's mantle.

The composition of molybdenum isotopes (atoms of the element with the same chemical properties but different numbers of neutrons) is noticeably different in the water-rich carbonaceous, or carbon-containing, material that originated from the outer Solar System and the dry non-carbon-containing material that originated from the inner Solar System. Before the collision with Theia, which originated in the outer Solar System, the Earth was composed of non-carbon-containing material.

"The molybdenum isotopes allow us to clearly distinguish carbonaceous and non-carbonaceous material, and as such represent a 'genetic fingerprint' of material from the outer and inner Solar System," said Budde.

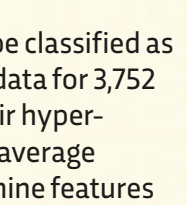
Since the composition of the molybdenum isotopes found in Earth's mantle lies somewhere in between that of carbon-containing and non-carbon-containing material, the team deduced that the mantle must contain large amounts of material from the outer Solar System. The amount of material brought by the collision with Theia would not only account for the molybdenum, but also for all of the water found on Earth, they say.

"Our approach is unique because, for the first time, it allows us to associate the origin of water on Earth with the formation of the Moon. To put it simply, without the Moon there probably would be no life on Earth," said Thorsten Kleine, professor of planetology at the University of Münster.

Crash debris: Earth's Moon and its water appear to originate from an astronomical collision that occurred aeons ago

6,400

The estimated diameter, in kilometres, of the astronomical body called Theia that collided with Earth 4.4 billion years ago.



42

The number of protons in a molybdenum nucleus

71%

The amount of Earth's surface covered by water

PALAEONTOLOGY

Tiny, bat-winged dinosaur sheds light on the origin of flight

Fossil finding shows evolution had an early alternative to feathers

> "The *Ambopteryx* fossil is more complete and proves that *Yi qi* wasn't an anomaly"

The recent unearthing of a previously unknown species of dinosaur is providing a new insight into the varied evolutionary paths that led to the development of flight.

Ambopteryx longibrachium was a 30cm-long beast that lived during the Jurassic Period (around 163 million years ago) in what's now northeast China. What marks *Ambopteryx* out is that it had membrane wings supported by a rod-like wrist structure, similar to those of today's bats but unlike almost all other types of dinosaur.

On the face of it, pterosaurs, which were also widespread at this time and were the first vertebrates to evolve true flight (a means of aerial locomotion, as opposed to simply gliding), would seem like an obvious comparison. But pterosaurs belong to a separate group of reptiles, instead of the same dinosaur lineage that eventually led to modern-day birds.

Ambopteryx, however, is a dinosaur and belongs to a family of small, possibly tree-dwelling creatures called the scansoriopterygids. Currently its closest relative is the *Yi qi*, another membrane-winged scansoriopterygid discovered in 2015. But as only partial remains of the *Yi qi* have been found, the nature of its wing structure could not be confirmed. The *Ambopteryx* fossil is more complete and proves that *Yi qi* wasn't an anomaly.

"These fossils demonstrate that, close to the origin of flight, dinosaurs closely related to birds were experimenting with a diversity of wing structures," write the researchers, led by Dr Min Wang at the Chinese Academy of Sciences. They say that these wings were probably a "short-lived experimentation" with flight. It's an example of convergent evolution, where animals independently evolve similar solutions to the same problem (in this case, flight). It was the feather-winged, bird-like dinosaurs who proved more successful, paving the way for the emergence of modern birds.

GETTY IMAGES, CHUNG-TAT CHEUNG ILLUSTRATIONS: TARA JACOBY

Mark Lynas Climate change researcher

Horizons

Could leaving nature to its own devices be the key to meeting the UK's climate goals?

A REPORT PUBLISHED BY ENVIRONMENTAL CHARITY REWILDING BRITAIN IS CALLING FOR VAST SWATHES OF THE UK'S LAND TO BE RESTORED TO NATURE IN ORDER TO REDUCE GREENHOUSE GAS EMISSIONS

WHAT EXACTLY IS REWILDING?

Rewilding is different from traditional nature conservation, where you have a nature reserve or one particular bird or plant that you're trying to preserve. What rewilding tries to do is bring back the wild over a larger area. To bring back nature in a more self-willed way, where ecosystems can begin to rejuvenate and restore the land so that species can more or less design their own ecosystems, rather than having humans defining every aspect of what should be a natural environment.

ARE SOME LANDSCAPES MORE SUITABLE THAN OTHERS?

In the Rewilding Britain report there was a lot of talk about the UK's unique ecosystems – particularly upland areas, the peat bogs or blanket bogs, which have been heavily degraded through draining, burning and overgrazing by sheep. These are huge areas of carbon draped across the tops of many upland areas that haven't been managed properly. These areas need to be rewetted so that the peat-forming vegetation can return. We need to get most of the grazing animals off them, so that the plants can grow, and let the bogs return to doing their thing, which is removing carbon from the atmosphere.

WHAT SCALE DO WE NEED TO DO THIS ON TO MAKE A SIGNIFICANT IMPACT ON GREENHOUSE GAS EMISSIONS?

We quantified it at about six million hectares. These were just indicative figures, but if we did that we could sequester about 10 per cent of the UK's emissions. Remember: we don't just have to cut emissions to net zero; we also have to reabsorb the accumulated carbon that is already up there if we're going to meet the climate change targets of 2°C or 1.5°C. How do you get that carbon back out of the atmosphere? Well, allowing rewilded ecosystems to begin to sequester carbon again is one of the options.

HOW DO THE FARMERS AND OTHER LANDOWNERS FEEL ABOUT THIS?

The thing about farming is that it's a business. The point of the Rewilding Britain report is that we're recognising that farmers need to be supported when we're looking at ecological restoration and carbon sequestration. These aren't things that you can expect farmers to do for free and still make money. There are business opportunities with diversification and ecotourism and so on, but you've always

NATURE PICTURE LIBRARY

"Don't worry, lads, I've got this!"

"We're recognising that farmers need to be supported when we're looking at ecological restoration"

got to think about how farmers make a living. If you're talking about livestock farmers and you're asking them to reduce stocking density, how do they continue to make a profit? The point of the report is to look at how we can restructure farming subsidies. Pretty much all upland farming (and a good deal of farming elsewhere) is supported by subsidies, which are paid by land area anyway. That doesn't support environmental objectives. We need to restructure these subsidies so that they not only support the environment, but also support farmers as they move towards more ecological types of land use, including rewilding.

HOW WILL THAT DIFFER TO CURRENT SUBSIDIES?

All farmers, pretty much, who have got substantial amounts of land will take up the subsidies because the hectarage payments are quite high. You get what's called basic payment and its hundreds of pounds per hectare under the European Union's common agricultural policy. Brexit, if it goes ahead, presents us with an opportunity: the UK will be leaving the common agricultural policy and, therefore, can design a new and more sustainable system for agricultural subsidies, which we're suggesting focuses hectarage payments on carbon sequestration. For example, if you're allowing a forest to regenerate on this grassland, how much carbon is it going to sequester? If you rewet this peat bog and then let it return to absorbing carbon, how many tonnes is it going to absorb per hectare? Put a price on that and you can pay the farmer accordingly.

CAN ANIMALS PLAY A ROLE IN THIS?

Absolutely, you don't have an ecosystem composed solely of plants. Certain species are considered keystone species, beavers are a good example of that. They are ecosystem engineers – they cut down trees along the edges of streams and build damns, they create new areas of wetland producing a habitat for lots of other species, such as fish and dragonflies. Beavers are an all-round good thing: they can improve the quality of the habitat and encourage it to sequester more carbon. Of course you need predator species as well – lynx, perhaps, and osprey, goshawks… A lot of species that would be present in a wilder, more natural habitat within the UK biome are not there and we should encourage them to return. Wild boar is another example, they're beginning to come back in some areas but they were extirpated several hundred years ago. The more species you get in an ecosystem, the more natural the food chain can become.

MARK LYNAS
Mark is a climate change researcher and author.
Interview by* BBC Science Focus *commissioning editor Jason Goodyer.

Mariana Trench, Pacific Ocean

OCEANOGRAPHY

OCEAN EXPLORER COMPLETES DEEPEST EVER DIVE

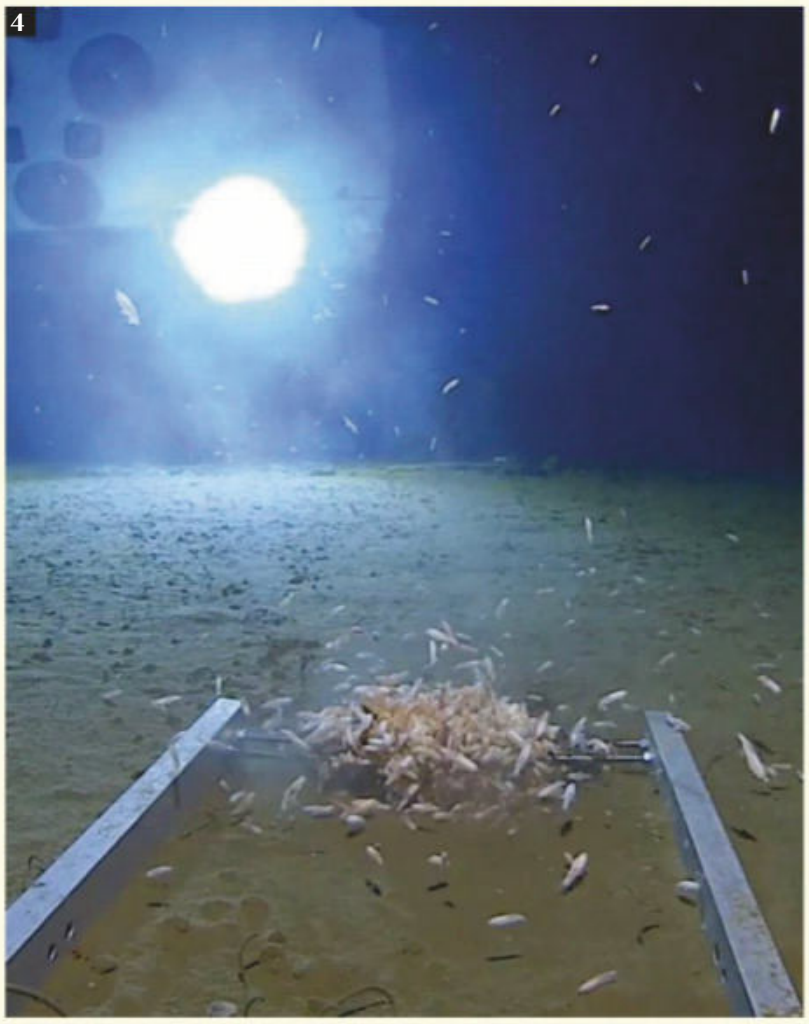
Privately funded expedition reaches the bottom of the Mariana Trench

1

2

On 28 April businessman and retired naval officer Victor Vescovo piloted the Limiting Factor deep-sea vehicle to the deepest known point in the ocean: the Mariana Trench's Challenger Deep. Reaching a depth of 10,928m, the dive bested the previous world record set by US Lieutenant Don Walsh and Swiss scientist Jacques Piccard in 1960 by 16m. The dive was part of the Five Deeps Expedition, a privately funded venture led by Vescovo that aims to dive to the deepest point in each of Earth's five oceans. The team has already completed dives to the Puerto Rico Trench in the Atlantic, the Java Trench in the Indian and the South Sandwich Trench in the Southern. They plan to head to the Molloy Deep in the Arctic for their fifth and final dive.

TAMARA STUBBS/REEVE JOLIFFE/FIVE DEEPS EXPEDITION



1. The Limiting Factor deep-sea vehicle was designed by Florida-based company Triton Submarines. Its 65kWh battery gives it enough power to dive for more than 16 hours. It can carry two people and has a hull that is 90mm thick and made of titanium alloy.

2. The team completed five dives to the bottom of the Mariana Trench, four dives to Challenger Deep and one dive to Sirena Deep, just over 200km to the northeast.

3. As well as being the first man to make multiple solo dives to the bottom of the Mariana trench, pilot Victor Vescovo is also the first man to have both climbed Mount Everest and skied to the North and South Poles.

4. Three new species of prawn-like amphipods are thought to have been discovered by the Five Deeps team over the course of their expedition.

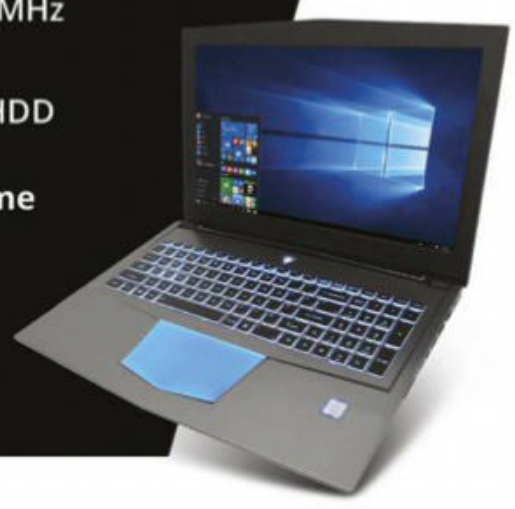
5. Expedition leader Rob McCallum, who has previously led expeditions to the *RMS Titanic*, holds his 'full ocean depth styrofoam cup'. Researchers exploring the ocean bottom often attach polystyrene cups to their vehicles. At depths of hundreds of metres the increased water pressure crushes them to a fraction of their former size leaving the researchers with a novel souvenir.

PC Specialist recommends Windows Windows 10

PROTEUS VI RTX

15.6" Matte Full HD IPS Screen
Intel® Core™ i7-8750H
16GB Kingston DDR4 2133MHz
8GB GeForce RTX 2070
1TB SEAGATE 7mm SATA HDD (7,200)
Genuine Windows 10 Home

This spec from
£1,349.99



VORTEX ELITE

PCS 6003B BLACK GAMING CASE
Intel® Core™ i3-8100
ASUS® H310M-A
8GB Corsair VENGEANCE 2400MHz
2GB GEFORCE GTX 1050
Genuine Windows 10 Home

This spec from
£529.99

DEFIANCE V RTX

17.3" Matte Full HD 144Hz Screen
Intel® Core™ i7-8750H
16GB Corsair 2133MHz
8GB GeForce RTX 2070 Max-Q
1TB SEAGATE 7mm SATA HDD (7,200)
Genuine Windows 10 Home

This spec from
£1,449.99

ILLUSION ELITE

THERMALTAKE V200 RGB TG
AMD Ryzen 7 2700X
ASUS® TUF X470-PLUS GAMING
16GB Corsair VENGEANCE 2400MHz
16GB AMD RADEON™ VII
Genuine Windows 10 Home

This spec from
£1,689.99

GET A FURTHER £15 OFF WITH THIS EXCLUSIVE VOUCHER CODE: **BBF19**

0333 011 7000

Some features require Windows 10. Update available through Windows Store. Internet access required; fees may apply.
Microsoft, and Windows are either registered trademarks or trademarks of Microsoft Corporation in the United States and/or other countries.

* Prices are including VAT and are correct at the time of printing, but subject to change.

/PCSPECIALIST @PCSPECIALIST

PCSPECIALIST

CUSTOM GAMING DESKTOPS & LAPTOPS

ORDER ONLINE NOW AT

WWW.PCSPECIALIST.CO.UK

SCIENCE BEHIND THE HEADLINES

REALITY CHECK

1 REVIEW

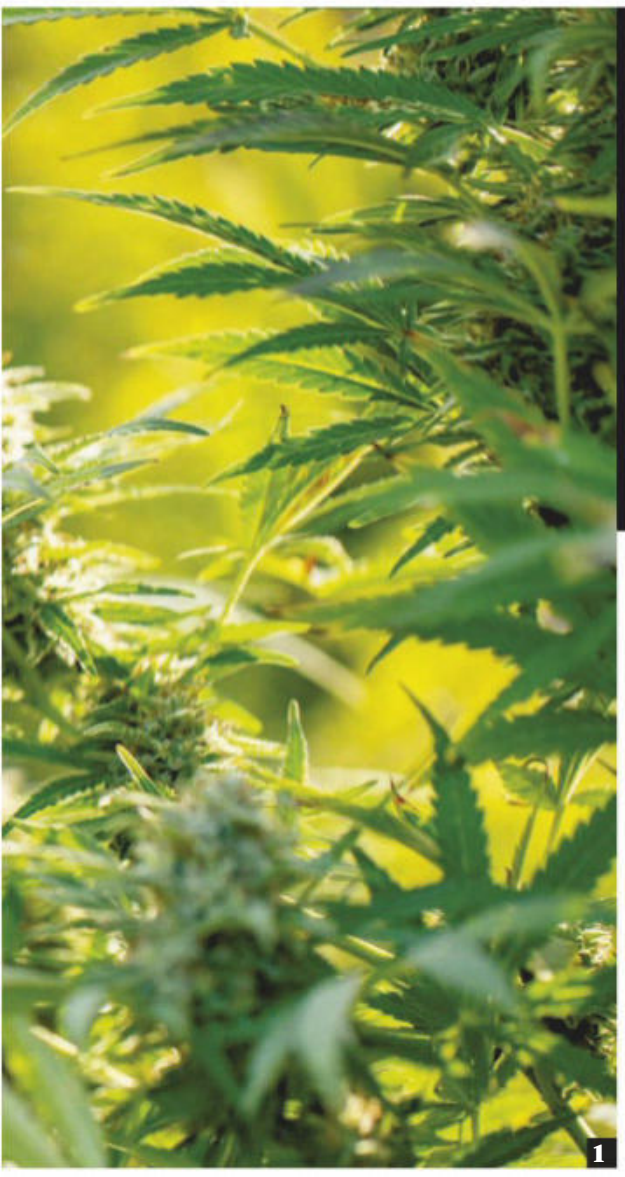
CBD OIL: MIRACLE CURE OR SNAKE OIL?

Derived from the cannabis plant, CBD oil is touted as a cure for everything from joint pain to epilepsy, with the global industry estimated to be worth almost £800m. But is it effective?

What is CBD oil?

The cannabis plant, *Cannabis sativa*, contains a number of active ingredients, including THC (tetrahydrocannabinol) and CBD (cannabidiol). THC, the most active ingredient of marijuana, is the component that makes a person high when either smoked or ingested. CBD, on the other hand, is not psychoactive: it doesn't induce a mind-altering effect.

To make CBD oil, the CBD is extracted from the plant, then diluted with a carrier oil like hemp seed. The oil can then be consumed, or mixed into food or drinks. In the UK, it can be found in health shops.



1

WANT MORE?

For more stories like this, visit our website at ***sciencefocus.com/realitycheck***

How does it work?

Cannabinoids mimic chemical messengers within our brain and body. More specifically, they have a similar structure to a type of naturally occurring neurotransmitter called endocannabinoids, which we know are involved in how the brain and body regulate pain, emotion, mood and other functions. This is still an area of active research and much of how it works is still being explored.

Many users of CBD oil claim it helps to relieve pain and inflammation, reduces anxiety and makes them feel calm. Currently, scientific studies cannot say whether the small CBD quantities available in CBD products have any effect, but that hasn't held back use. This is an area of ongoing research – we just haven't reached a point where we have all the answers.

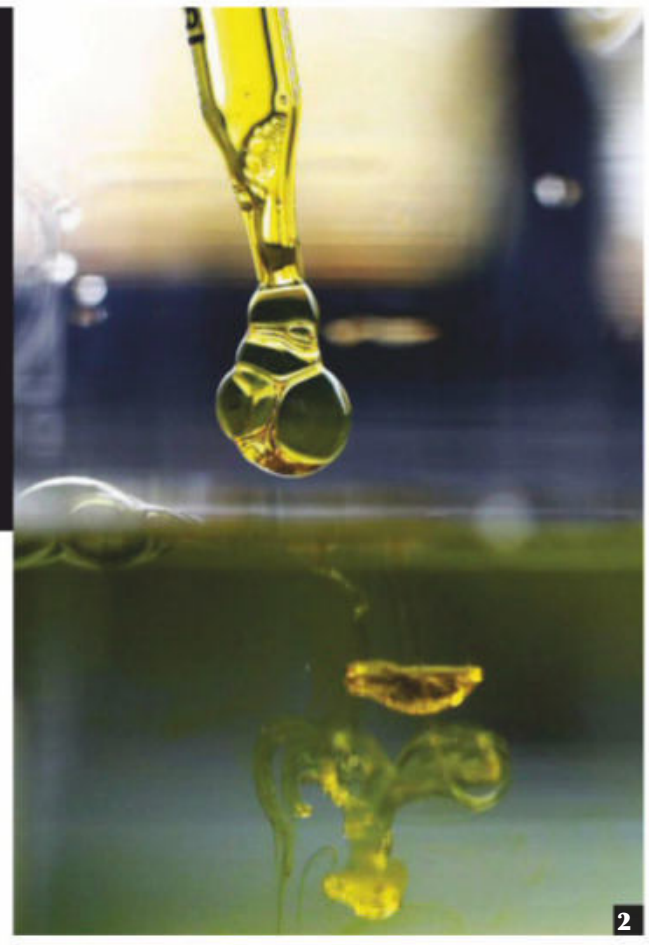
CBD products available in health food shops and on the internet are not controlled or regulated as medicines, other than the legal limit on THC content (see box, left). As doctors, we are advised to tell patients that 'over-the-counter or internet' CBD products lack quality assurance and should not be treated as medicines. There's no way to be sure of what's in the products you buy.

What conditions can it help?

The list of things we're told CBD oil can do for us is long, but there's still only preliminary evidence. There is some belief that CBD is a natural painkiller. It's also thought to have anti-inflammatory properties, and so it may help conditions like Crohn's disease. Indeed, some small studies in mice have supported this claim by showing that CBD significantly reduced chronic inflammation and pain. We won't know if it can help treat chronic pain in people until human tests are complete.

1 Researcher harvesting cannabis buds from a plant

2 Water-soluble CBD oil



2

CBD is believed to help people who suffer from anxiety and mood-related symptoms, as well as insomnia.

The condition that brought CBD oil to prominence is epilepsy. Scientific reviews have found that CBD has anti-seizure properties and there are several clinical trials well underway, some of which use pure CBD product. Stronger forms of CBD have been found to reduce the number of epileptic seizures suffered by some patients by more than 40 per cent. This has resulted in parents of children suffering with severe epilepsy buying illegal forms of high-strength cannabidiol CBD oil online.

Initial research published in the *Journal Of Alzheimer's Disease* found that CBD may one day help people in the early stages of Alzheimer's by helping them retain the ability to recognise the faces of people that they know. Researchers from the National Institute for Health Maudsley BRC are conducting a study to see if a cannabis-based treatment containing CBD can ease symptoms of agitation and aggression in patients with Alzheimer's, where at the moment treatment options are limited.

by **BY SALEYHA AHSAN**

Saleyha is an A&E doctor in North Wales. She presents BBC programmes like Trust Me, I'm A Doctor *and* Panorama.

Is CBD oil legal?

The vast majority of cannabinoids, listed as controlled substances under the Misuse of Drugs Act, are illegal. However, CBD derived from industrial hemp that is EU-approved is completely legal in the UK, under certain conditions. The strain must contain no more than 0.2 per cent THC, and the THC must not be easily separated from it. In contrast, cannabis oil, which has a higher THC content than CBD oil, is not legal.

With the change of law in November 2018, specialist clinicians are allowed to prescribe cannabis-derived medicinal products for some patients with multiple sclerosis or epilepsy.

DISCOVER MORE

BBC

Visit the BBC's Reality Check *website at* ***bit.ly/reality_check_*** *or follow them on Twitter* ***@BBCRealityCheck***

GETTY IMAGES X2

2 ANALYSIS

BODY POSITIVITY: DOES IT STILL ENCOURAGE US TO SCRUTINISE OUR BODIES?

We should stop feeling positive or negative about our bodies, and just feel neutral instead

The body positivity movement advocates loving your body, even if it doesn't conform to beauty standards. But should we encourage people to stop worrying about their bodies altogether?

One in five adults in the UK felt shame over their body at some point in the last year, according to a new survey carried out by the Mental Health Foundation for Mental Health Awareness Week (13-19 May 2019). This year's theme was body image, and the research confirmed how necessary it was: as many as one in eight people have experienced suicidal thoughts or feelings as a result of their body image.

The body positivity movement, bolstered by the emergence of social media, encourages people to push back against the pressures on their body image. It urges its followers to love their body, regardless of size, shape, age, skin colour or any other aspect of their appearance. People of all genders – not just women – flock to hashtags like #BoPo to celebrate their bodies as they are, even when they fall outside of the ideals pushed by advertising and the media.

Body positivity encourages diversity in beauty, but it can still make us fixate on our appearance

It is an attractive concept, with more than 13 million Instagram posts tagged as #BodyPositivity, #BodyPositive or #BoPo. Celebrities and brands are also picking up on the message, championing campaigns that display diverse models.

That said, brands that advocate body positivity don't always follow through. "We sometimes see campaigns which will use body-positive language, but then still don't represent much diversity in terms of the imagery they're showing," says Prof Phillippa Diedrichs at the Centre for Appearance Research, University of the West of England. "Sometimes they'll have 'love your body' hashtags or slogans. But actually, across the board, a particular brand's advertisements might be limited to a one-off campaign, for example, or it might not be carried through in terms of the types of products they offer."

Even so, it seems to work: a study led by Rachel Cohen at the University of Technology Sydney found that after viewing a selection of body positive posts on Instagram, young women reported feeling happier and more satisfied with their bodies. But the study also found that the women seemed to objectify themselves more.

Diedrichs notes that the link here may be that some of the body-positive content still puts the emphasis on appearance. "There's still a lot of discussion about controlling your body through weight and through exercise," she explains. "But, importantly, we also know that when people experience body positivity, it can protect them against some of the negative impacts of other types of media imagery."

Although self-objectification can affect anyone, it is most commonly found among young women, and the consequences can be severe. The research around the topic highlights the risks over and over again: objectifying yourself leads to drawing your sense of self-worth from your appearance; focusing on your appearance makes you more susceptible to body shame; self-objectification appears to be a cause of depression, particularly among young women and adolescents.

"It's not to say that appearance should be irrelevant, but it's just thinking about the role that appearance plays, so that all of your self-worth is not tied up into this outer shell"

So, does that mean that engaging with body positivity on social media could do more harm than good? "What's important is thinking about the types of body-positive content as well, rather than just lumping all of that together in one bucket," says Diedrichs.

When it comes to encouraging a healthy body image, there is no one-size-fits-all approach. "I wouldn't encourage a blanket statement saying everyone needs to love their bodies to experience the benefits of having positive body image," says Diedrichs. "Positive body image is much more about having respect for your body and appreciating your body, which I think is very different from this idea that you have to be confident and love every aspect of it.

"It's not to say that appearance should be irrelevant, but it's just thinking about the role that appearance plays, so that all of your self-worth is not tied up into this outer shell."

by **SARA RIGBY**

Sara is the online assistant for BBC Science Focus. *She has an MPhys in mathematical physics.*

GETTY IMAGES

NEED TO KNOW
Prof Diedrichs: how to have a healthy body image

BE WARY OF THE LANGUAGE YOU USE
Try not to reinforce appearance ideals. For example, don't always tell young girls that they look pretty. Also, don't comment on your friends' appearances all the time.

BE CRITICAL OF THE SOCIAL MEDIA ACCOUNTS THAT YOU CONSUME
Cultivate social media feeds that make you feel good about yourself. Stay away from ones that trigger comparisons to other people, or are really saturated with narrow appearance ideals.

APPRECIATE YOUR AMAZING BODY FOR WHAT IT DOES
Remember that your body helps you to get through life. It allows you to hug your loved ones, it lets you use your hands to express yourself and to engage in creative pursuits.

HOLD BRANDS ACCOUNTABLE FOR THE IMAGES THEY PORTRAY
With social media, we have a tool for activism in our back pockets. Engage in direct discussions with brands and businesses. Tell them when we don't like what they're showing, but also applaud steps in the right direction as well.

Prof Phillippa Diedrichs

3 COMMENT

CHERNOBYL: HAS THE AREA RECOVERED SINCE 1986's NUCLEAR DISASTER?

The historical drama *Chernobyl* is inspiring people to visit the nuclear disaster zone – but is it safe?

More than three decades after the Chernobyl accident, many people – not least tens of thousands of 'disaster tourists' who now visit the site – want to know: is the area safe? HBO's recent dramatisation *Chernobyl* showed the horrors of the accident itself, but what are the radiation risks to people visiting the area and what has happened to the wildlife?

Wildlife in Chernobyl appears to be flourishing, thanks to an absence of humans

In the early hours of 26 April 1986, the Chernobyl number 4 reactor suffered what remains the world's worst nuclear accident. By early May, nearly 120,000 people had been evacuated from the 'Chernobyl Exclusion Zone' (CEZ) – an area almost the size of Northumbria – around the Chernobyl site. This area remains abandoned today.

Radiation is scary, conjuring up images of atomic bombs, mutation and cancer, but we tend to forget that we are all continuously exposed to natural radioactivity from soil and rocks. Even air travel exposes us to radiation coming from space. Chernobyl tourists (who do not visit the most contaminated 'hot spots') do get a small increase in their radiation dose but this is similar to the cosmic radiation dose they received on their flight to Ukraine. Our calculations show that the inhalation dose people get in most of the CEZ is lower than in places like Cornwall that have higher-than-average natural radiation. As long as visitors to the CEZ use common sense, it is now safe to visit.

Animals and plants live in the CEZ year-round and get higher radiation doses than tourists. The effects of radiation on wildlife in the CEZ is a contentious issue. Straight after the accident, radiation levels were about 100 times greater than they are now and there were significant impacts. The best-known is an area of betweeen four and six square kilometres where pine trees received enough radiation to kill them. Their needles turned reddish-orange and Soviet scientists named the area the 'Red Forest'.

The CEZ now has much lower radiation levels and is home to large wildlife populations, including many rare species, as documented in the final dramatic scene of David Attenborough's *Our Planet*. Most studies have found subtle, if any, effects on wildlife. Our studies support this, showing that there may be radiation effects at the most contaminated sites. This includes the Red Forest, but we know that this highly contaminated area has not fully recovered from the damage done in 1986. We are still unsure if effects observed now in the Red Forest are due to current exposure rates, or are a residual effect of much higher dose rates in 1986, or are due to poor habitat quality.

The vast majority of the CEZ wildlife is flourishing, not because radiation is good for the ecosystem, but because of the virtual absence of human activities for more than 30 years. In the Belarussian part of the CEZ, numbers of large mammals have increased since 1986 and are comparable to those in nature reserves elsewhere in Belarus. In the Ukrainian sector, more than 400 species of vertebrates have been recorded. Our large motion-activated camera study has recorded 16 species of medium to large mammals including brown bear, European bison, Przewalski's horse, wolf and lynx. The species observed were basically the same in areas of different contamination, including the Red Forest. The animals appear healthy. In the case of Przewalski's horse, introduced into the CEZ in the mid-1990s, the population is successfully breeding and we have evidence of long lives.

Despite misleading headlines, Chernobyl is recovering. Back in 2006, the World Health Organization identified that the social and psychological impacts of Chernobyl on people have been greater than the health effects from radiation. In a world threatened by a multitude of environmental hazards, Chernobyl still has much to teach us about our understanding of risk and about the recovery of natural ecosystems when the pressure of human habitation is removed.

"The social and psychological impacts of Chernobyl on people have been greater than effects from radiation"

by **PROF NICK BERESFORD** *(@radioecology)* and **PROF JIM SMITH**

Nick is the environmental contaminants group leader at the Centre for Ecology & Hydrology. Jim is a professor of environmental science at Portsmouth University. They both research Chernobyl and the CEZ and co-wrote Chernobyl: Catastrophe And Consequences.

NICK BERESFORD/JIM SMITH

FOLLOW THE CONVERSATION

@GOrizaola
Germán Orizaola is a senior researcher at the Research Unit on Biodiversity (UMIB). He studies the microbiome of Chernobyl.

@clairecorkhill
Dr Claire Corkhill researches nuclear waste for the Research Unit on Biodiversity (UMIB).

@ChernobylG
Chernobyl Gallery regularly posts news updates, photos and videos about Chernobyl and the surrounding area.

@ProfMikeWood
Mike Wood is an environmental scientist at the University of Salford, studying the wildlife in Chernobyl.

SFP337

BBC **Science Focus** MAGAZINE

SUBSCRIPTION ORDER FORM

Please complete the order form and send to:
FREEPOST IMMEDIATE MEDIA *(please write in capitals)*

UK DIRECT DEBIT

☐ Yes, I would like to subscribe to/renew *BBC Science Focus* paying £17.95 every 6 issues – saving 40% *

YOUR DETAILS (ESSENTIAL)**

Title _____ Forename _____

Surname _____

Address _____

_____

_____ Postcode _____

Home phone no _____

Mobile phone no** _____

Email** _____

☐ **I wish to purchase a gift subscription**
(please supply gift recipient's name and address on a separate sheet)

Instructions to your bank or building society to pay by Direct Debit

DIRECT Debit

To: the Manager (bank/building society)

Address

Postcode

Name(s) of account holder(s)

Bank/building society account number

Branch sort code

Reference number (internal use only)

Originator's identification number

7 1 0 6 4 4

Please pay Immediate Media Co Bristol Ltd debits from the account detailed in this instruction subject to the safeguards assured by the Direct Debit Guarantee. I understand that this instruction may remain with Immediate Media Co Bristol Ltd and, if so, details will be passed electronically to my bank/building society.

Signature

Date / /

Banks and building societies may not accept Direct Debit mandates from some types of account

KEEP IN TOUCH

***BBC Science Focus Magazine* (published by Immediate Media Company Limited) would like to send you updates, special offers and promotions by email. You can unsubscribe at any time. **Please tick here if you would like to receive these** ☐

We would also like to keep in touch by post and telephone about other relevant offers and promotions from Immediate Media. If you do not wish to be contacted this way please tick here post ☐ phone ☐. For more information about how to change the way we contact you, and how we hold your personal information, please see our privacy policy which can be viewed online at **immediate.co.uk/privacy-policy**

OTHER PAYMENT METHODS

☐ **UK cheque/credit/debit card** – £52.40 for 14 issues, **saving 25%**

☐ **Europe** inc Eire – £73.35 for 14 issues

☐ **Rest of world** – £74.75 for 14 issues

☐ I enclose a cheque made payable to Immediate Media Co Ltd for £ _____

Visa ☐ Mastercard ☐ Maestro ☐

☐☐☐☐ ☐☐☐☐ ☐☐☐☐ ☐☐☐☐ ☐☐☐☐

Issue no ☐☐ Valid from ☐☐☐☐ Expiry date ☐☐☐☐

Signature _____ Date _____

If credit card address is different, please use the order hotline 03330 162 113

OVERSEAS Please complete the order form and send to: *BBC Science Focus Magazine*, PO Box 3320, 3 Queensbridge, Northampton, NN4 7BF

***Offer ends 17 July 2019.** 40% saving is only available to UK residents paying by Direct Debit. Your subscription will start with the next available issue.

You may photocopy this form

SAVE 40%

INTRODUCTORY OFFER WHEN YOU SUBSCRIBE TO *BBC SCIENCE FOCUS MAGAZINE* TODAY *

- **Save 40%** on an annual subscription
- **Pay just £17.95** every 6 issues by Direct Debit, **saving 40%!***

Receive every issue delivered direct to your door with FREE UK delivery

Online	Phone	Post
buysubscriptions.com/SFP337	**03330 162 113+** (please quote SFP337)	**FREEPOST IMMEDIATE MEDIA** (please write in capitals)

+ UK calls will cost the same as other standard fixed line numbers (starting 01 or 02) and are included as part of any inclusive or free minutes allowances (if offered by your phone tariff). Outside of free call packages, call charges from mobile phones will cost between 3p and 55p per minute. Lines are open Mon to Fri 8am-6pm and Sat 9am-1pm. *If calling from overseas, please call +44 1604 973 721.*

SALT OF THE EARTH

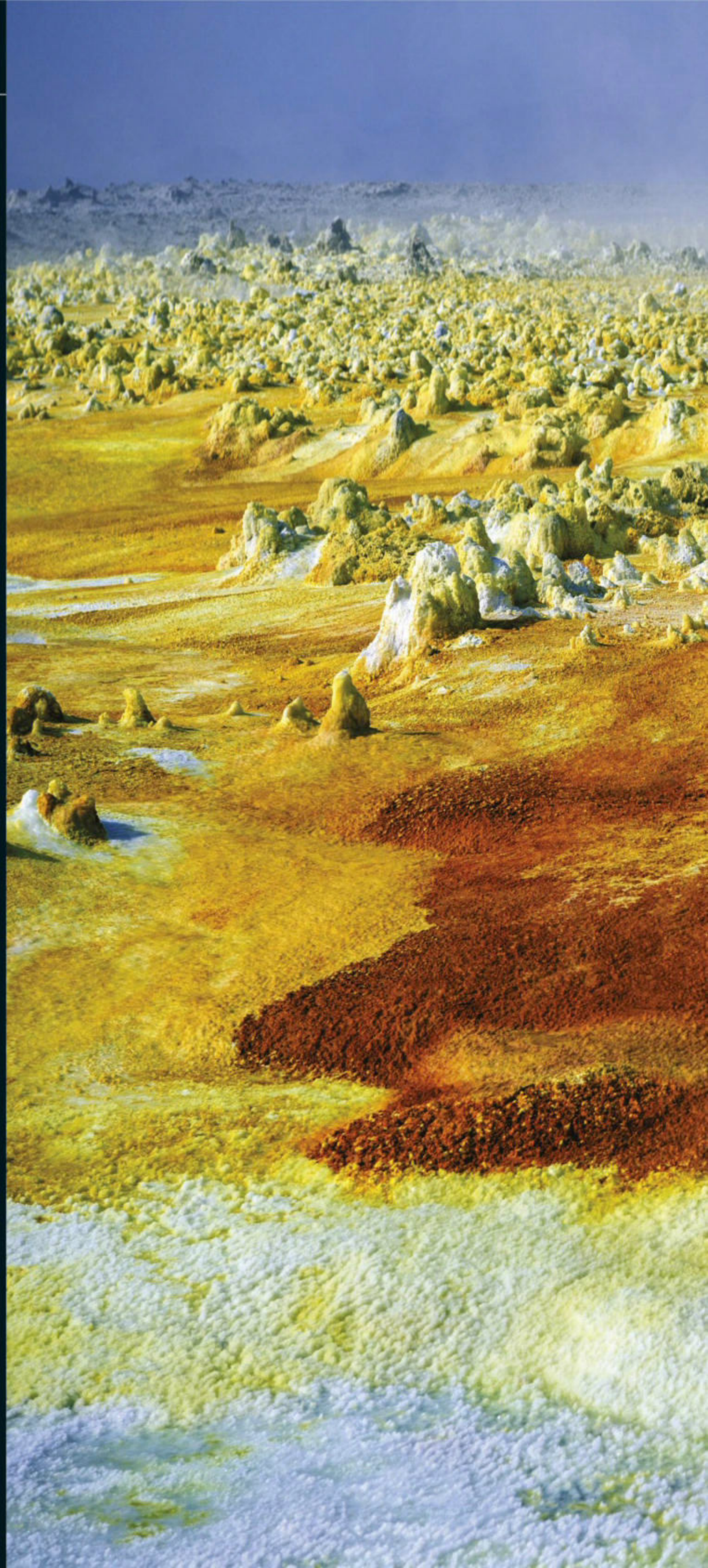
SALT HAS A LIFE FAR BEYOND THE DINNER TABLE. FROM LAND SPEED RECORDS TO ANCIENT LAKES, THIS MINERAL IS INTIMATELY TIED TO OUR LIVES AND OUR LAND

Words: HAYLEY BENNETT

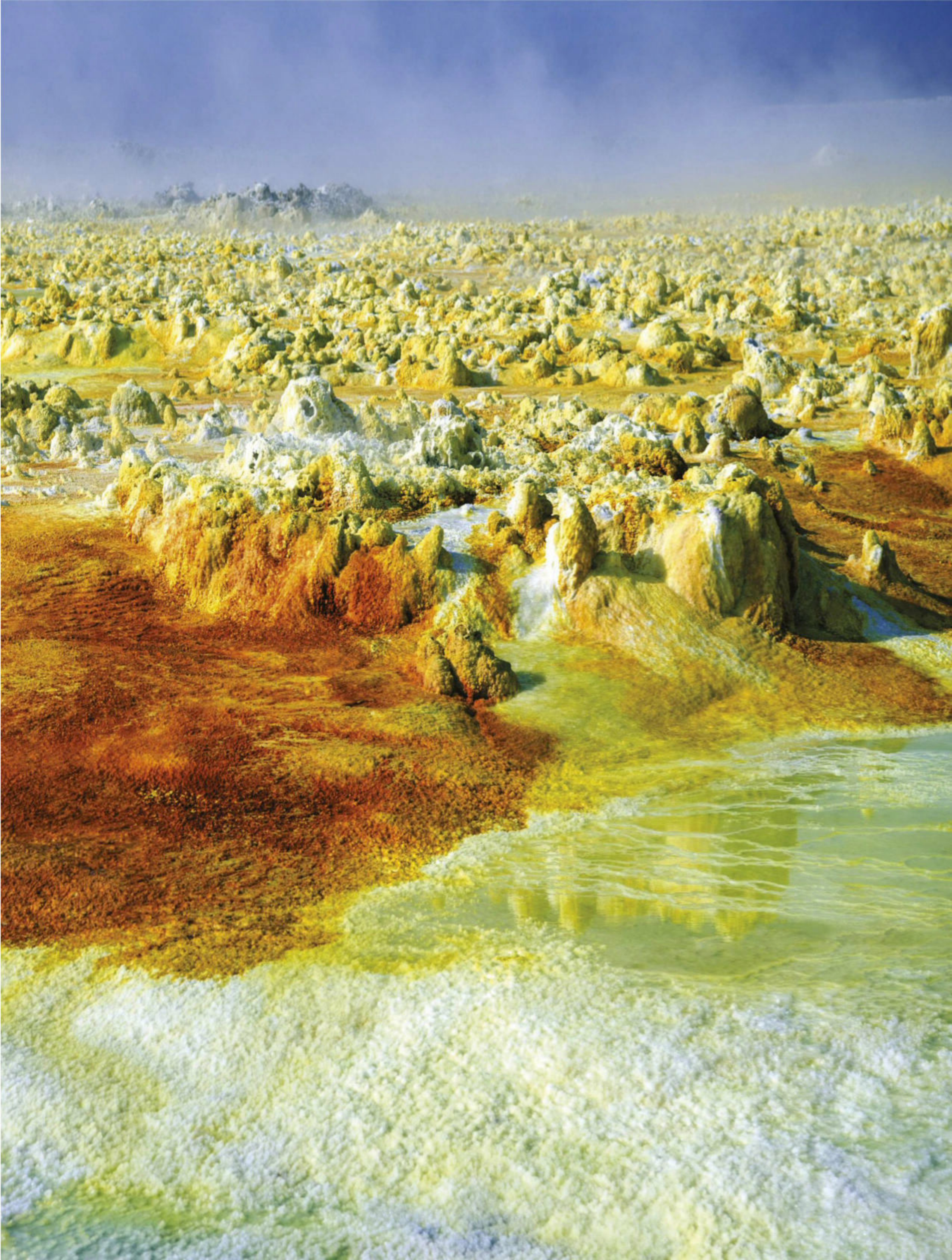
SCORCHING SALT

→ **DANAKIL DEPRESSION, ETHIOPIA**

The Danakil Depression near Dallol, Ethiopia, is an alien landscape on Earth. At 100 metres below sea level, the cratered ground barely contains the volcanic activity beneath it, spitting out hot water that dissolves salt and other minerals. It's stiflingly hot and dry – approaching 50°C some days – and the ejected water quickly evaporates, leaving behind vibrant-coloured deposits. Sulphurous yellows mingle with iron-rich browns and turquoise tints of copper in boiling pools. It's no place for hard physical labour, but that hasn't deterred the hundreds of workers – Afar people – who come here with axes to cut the salt into slabs, known as 'tiles', for $5 a day. Although trucks are now allowed in to transport the tiles, the Afar people are wary of the encroachment of modern technology, which could devalue the products of their traditional trade.



GETTY IMAGES



DEAD LOSS

DEAD SEA, ISRAEL/JORDAN ↓

The Dead Sea is a health tourism hotspot for those who believe in the medicinal benefits of a natural salt bath. The water here is about 10 times saltier than open seawater, partly because the salt has nowhere else to go – this 'sea' is actually a saltwater lake trapped in the Jordan Rift Valley. And with water levels dropping by more than one metre per year, it's getting even saltier.

Dr Nadav Lensky, who heads up the Dead Sea Observatory in Jerusalem, says it's likely that human activity rather than natural processes will determine how far levels drop and if the lake will eventually dry up. The potash industry has a big impact on the lake, pumping water from the deeper northern basin to the southern shallows to create evaporation pools for producing potassium salts that are used in fertiliser. In this image, trees and bushes that once grew on dry land perish in the southern end's salty pools.

ABSTRACT ALGAE

SOUTHERN FRANCE →

This striking image may resemble abstract art, but it's actually a drone photograph of the salt ponds of southern France. Across this artificially created landscape, saltwater is channelled into shallow pools; each is at a different stage of drying. Once you know what you're looking at, the white shapes reveal themselves as crusts of dried-out salt separated by dirt roads. The broad expanses of red and pink, meanwhile, are the colours of communities of microbes living in the ponds. At lower levels of salinity, blue-green algae dominates, but as evaporation draws the water out, the colours change to those of species that can withstand the saltiest of saltwater. Orange and red pigments called beta-carotenes are the chemicals made by salt-tolerant organisms like the algae *Dunaliella salina* and halobacteria. Brine shrimp also make versions of the same pigments, adding to the vivid colour palette.

ALAMY, TOM HEGEN


123
SCS-W
Mountain Pies by BeauJos Colorado Style Pizza
A123 SYSTEMS
Cummins Onan
THE UNIVERSITY OF AUCKLAND NEW ZEALAND
PARTSBIANT
A123 SYSTEMS
DENVER
A123 SYSTEMS
123
SCS-W
GASOLINE?! THAT'S SO LAST CENTURY!
KILLA
NSK
3D
New Eagle
Avon Aero
chargenetwork

FLAT OUT

BONNEVILLE SALT FLATS, UTAH ←

As any speed junkie worth their salt will tell you, Bonneville is the place to be if you're serious about speed. The salt flat pictured here, measuring 10,000 square kilometres, is a remnant of Lake Bonneville, a giant salt lake that dried up 14,500 years ago. Engineer Eva Håkansson is gearing up her electric motorcycle 'KillaJoule' to compete in the 2017 Bonneville Motorcycle Speed Trials. While the salt doesn't make for a pleasant ride – it's rougher than regular roads and at high speeds you feel every bump – it does provide a vast, featureless plain to race on. "There's nothing to hit and no neighbours to disturb," says Håkansson. At the 2017 trials, she reached 411km/h (255mph), leaving her petroleum-powered competition for dead. But she says such speeds may become harder to achieve in future, as climate change will interfere with conditions on the salt.

ALAMY

ROSE-TINTED VIEW

KHEWRA, PAKISTAN ↑

The rose-coloured tinge of these slabs of Himalayan salt gives them the appearance of sugar-dusted Turkish delight. The salt, which is mined at the Khewra Salt Mine in the westernmost tip of the Himalayas, is one of Pakistan's most famous exports. Miners work by the light of gas lamps, using gunpowder to blow it from the walls. After being cut into slabs, the salt is transported by truck to Karachi, some 20 hours' drive away. In the UK, Himalayan pink salt sells for around twice the price of regular table salt. Claims about its health benefits abound, with articles citing its 84 trace minerals. There are no scientific studies to back up these claims, but the mineral content explains why the salt is the colour of confectionery.

by HAYLEY BENNETT *(@gingerbreadlady)*
Hayley is a Bristol-based science writer and editor. She is the co-author of The Big Questions In Science *(£5.99, Andre Deutsch).*

HARVEST TIME

BAC LIÊU PROVINCE, VIETNAM →

The coastal province of Bac Liêu, Vietnam, is the size of Luxembourg, and roughly one-tenth of its land is devoted to producing salt. The salt fields are flat and open, allowing seawater to wash across. Hot, dry conditions make the water evaporate quickly, meaning more salt. In the rainy season, salt output declines. This area produces up to 165,000 tonnes of salt a year, enough for over 350 billion packets of ready salted crisps. The back-breaking work of raking the salt into piles and carrying it away in baskets is done by farmers in the blazing heat; they will often work from sunrise to sunset. Most don't have space to store what they harvest, so the market value is dictated by dealers who stockpile the salt until they can sell it at a good price. SF

LUKE DUGGLEBY, TUAN NGUYEN

Technicolour dinosaurs

NEW DISCOVERIES OF DINOSAURS' COLOURS AND PATTERNS ARE REVEALING HOW THESE ANCIENT BEASTS LIVED

by JOHN PICKRELL

Eight years ago, as a bitter cold gripped the forests north of Alberta, Canada, a worker in a bitumen mine noticed a clang as his excavator hit something unexpected. Rocks of an unusual colour tumbled into view. Quite by chance, he had stumbled upon the most exquisitely preserved fossil of an armoured dinosaur ever discovered – a species of ankylosaur that in 2017 would be named *Borealopelta*.

After being unearthed, the 110-million-year-old fossil ended up at the Royal Tyrrell Museum of Palaeontology in Drumheller, Alberta, where technicians spent 7,000 hours over the next six years chiselling away the rock entombing it. What they revealed looks more like a statue than a fossil – the preserved specimen includes much of the nearly six-metre-long animal, from its head to its hips, including remains of skin, armour plates and spikes. But it was dark smears that caught the attention of University of Bristol palaeobiologist and fossil colour expert, Dr Jakob Vinther. Analysis of the smears revealed traces of a reddish pigment, indicating the dinosaur's skin colour. *Borealopelta* had entered the select group of dinosaurs to have their true colours revealed.

Skin and feather colours and patterns might seem like superficial details, but they could help rewrite our understanding of how dinosaurs lived and behaved. Today, animals use colour for camouflage, communication, attracting mates and warding off predators. Dinosaurs almost certainly did, too.

We now know the colours of a handful of dinosaurs, including *Borealopelta*, the *Caihong* (this month's cover star) and the ▶

ILLUSTRATION: MAGIC TORCH

"DINOSAUR EXPERTS ARE POURING OVER THESE LATEST FINDS TO REVEAL SURPRISING INSIGHTS INTO THESE CREATURES' LIVES"

Sinosauropteryx. Improved technology promises to reveal many more. In the meantime, dinosaur experts are poring over these latest finds to reveal some surprising new insights into these creatures' lives.

SHADY SCIENCE

When Vinther was invited to Drumheller to see the *Borealopelta* fossil in December 2016, he dropped everything. "It's a spectacular specimen," he says. "It was very emotional, because it's just so lifelike – it really feels alive when you see it."

Even more exciting were the traces of reddish pigment that Vinther found when he analysed samples of the fossil. This pigment, called phaeomelanin, belongs to a group of natural pigments known as melanin, which are responsible for the colours of the skin, feathers, scales, hair and fur of animals (and red-headed humans) today.

More intriguing, however, was evidence of a pattern of colouration called countershading, which is common in the natural world today. Many modern animals have countershading – a form of camouflage where the animal's back or upper surface is darker than the underside. In the case of *Borealopelta* (see illustration, overleaf), far more phaeomelanin was present in the skin tested on the back than the fossil's lower surface. Generally, sunlight will make the upper surface of an animal lighter than the underside. By having shading that reverses this gradient, the animal appears flatter to predators, helping it to blend into the shadows.

Computer illustration of B*orealopelta* (main image), and photos taken of the fossil (left)

HOW IT WORKS: COLOURING IN A DINOSAUR

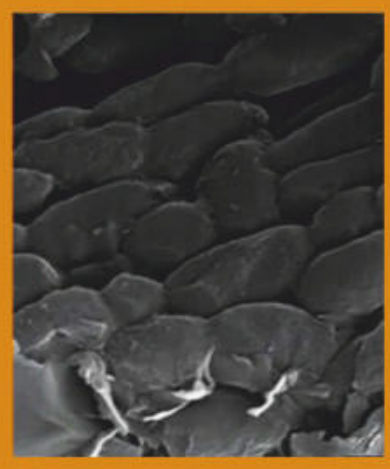
It took many years to bring the vibrant *Caihong juji* back to life

1. Fossil discovered

A farmer called Yang Jan in the northeast of China found a beautiful duck-sized fossil specimen that the Paleontological Museum of Liaoning acquired in 2014. Scientists carefully chipped away rock to reveal superbly preserved feathers. Based on the fossil's location, the experts realised that the dinosaur must be about 160 million years old, from the Late Jurassic.

2. Fossil analysed

Palaeontologists led by Dongyu Hu, a professor at Shenyang Normal University, found that the feathers were so well preserved that they could use a scanning electron microscope to reveal tiny structures called melanosomes. In life, these would have been filled with the pigment melanin. Melanosomes are so small that 200 would fit across the width of a human hair.



3. Comparisons made

The palaeontologists compared the fossil's melanosomes to those of modern animals and found that some on the dinosaur's head, breast and tail resembled those of hummingbirds. The shape of these pigment-holding structures hinted that they once held black melanin, but they were also flat and hollow. In hummingbirds, this design refracts light like a prism, generating a metallic rainbow sheen.

4. *Caihong juji* in living colour

Working with palaeoillustrator Velizar Simeonovski, who studies the anatomy of fossil creatures to paint lifelike reconstructions, the scientists were able to create an image of this vibrant little carnivore. Dongyu Hu and his co-workers called the species *Caihong juji* ('crested rainbow' in Mandarin) and published their thrilling discovery in January 2018 in the journal *Nature Communications*.

JOKOB VINTHER/UNIVERSITY OF BRISTOL/BOB NICHOLLS/PALEOCREATIONS.COM X2, VELIZAR SIMEONOVSKI/THE FIELD MUSEUM, HU ET AL 2018, GETTY IMAGES

"If you take any wild mammal that is less than a couple of kilos, 100 per cent of them will have countershading," says Vinther. "Basically, all animals have it unless they are too big to worry about predators."

This is what makes the discovery of countershading in a 1.3-tonne, armoured dinosaur so surprising. "Having an ankylosaur that needed countershading means the predator-prey landscape in the Cretaceous was very, very different," says Vinther. "There were some scary predators around. Even if you were armoured to your teeth, you were not safe."

Borealopelta is far larger than any animal that requires countershading today, probably because it had to evade predators such as the 11-metre-long, six-tonne *Acrocanthosaurus* that terrorised what is now Canada during the mid-Cretaceous.

Vinther and his colleagues have found similar countershading in two other dinosaurs: *Sinosauropteryx* and *Psittacosaurus* (see illustration, overleaf). *Sinosauropteryx* was a long-tailed, turkey-sized meat-eater that lived 124 million years ago in northeastern China and sported a gingery-brown coat of downy feathers, with a dark back and lighter underbelly. It also had white tail stripes like a ring-tailed lemur and a bandit mask across its eyes, similar to a raccoon. *Psittacosaurus*, also from China, was a primitive herbivore and an early relative of *Triceratops*. It was about the size of a golden retriever and had red-brown scaly skin and bristle-like feathers emerging from its tail. It seems that *Psittacosaurus* was countershaded in a slightly different pattern to *Sinosauropteryx*, with the dark colouration reaching lower down on its body. Palaeontologists think that *Psittacosaurus*'s patterning was best suited to a dense, forested environment with more diffuse light, while *Sinosauropteryx* may have lived in more open, lake-side environments that had direct light and strong shadows.

FLIGHTS OF FANCY

The first dinosaur colour discoveries were made in 2010 by two competing groups, one led by Vinther, then at Yale University in the US, and the other by palaeontologist Prof Mike Benton at the University of Bristol. Benton's team found evidence of the gingery hue in *Sinosauropteryx*, while Vinther's team mapped out black, white and grey feathers and ➤

Dinosaurs: now in colour

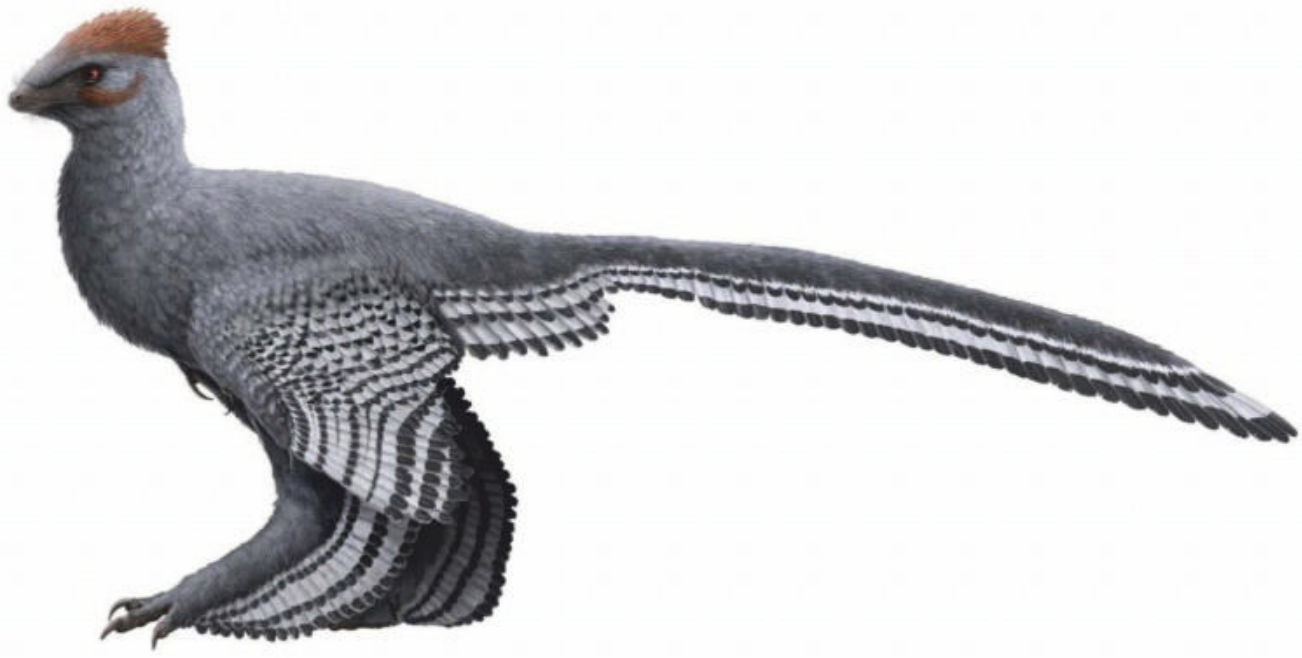
So far, seven dinosaurs have had their colours or patterns revealed by scientists

Microraptor gui

Length: Up to 80cm, with a 1m wingspan
Weight: 1kg
Lived: Northeastern China, early-Cretaceous (120 million years ago)

Four-winged relative of *Velociraptor* that glided and flapped between the trees.

Most dinosaurs are only known from a single fossil, but more than 300 skeletons of *Microraptor* have been found, suggesting it was abundant in its ecosystem.

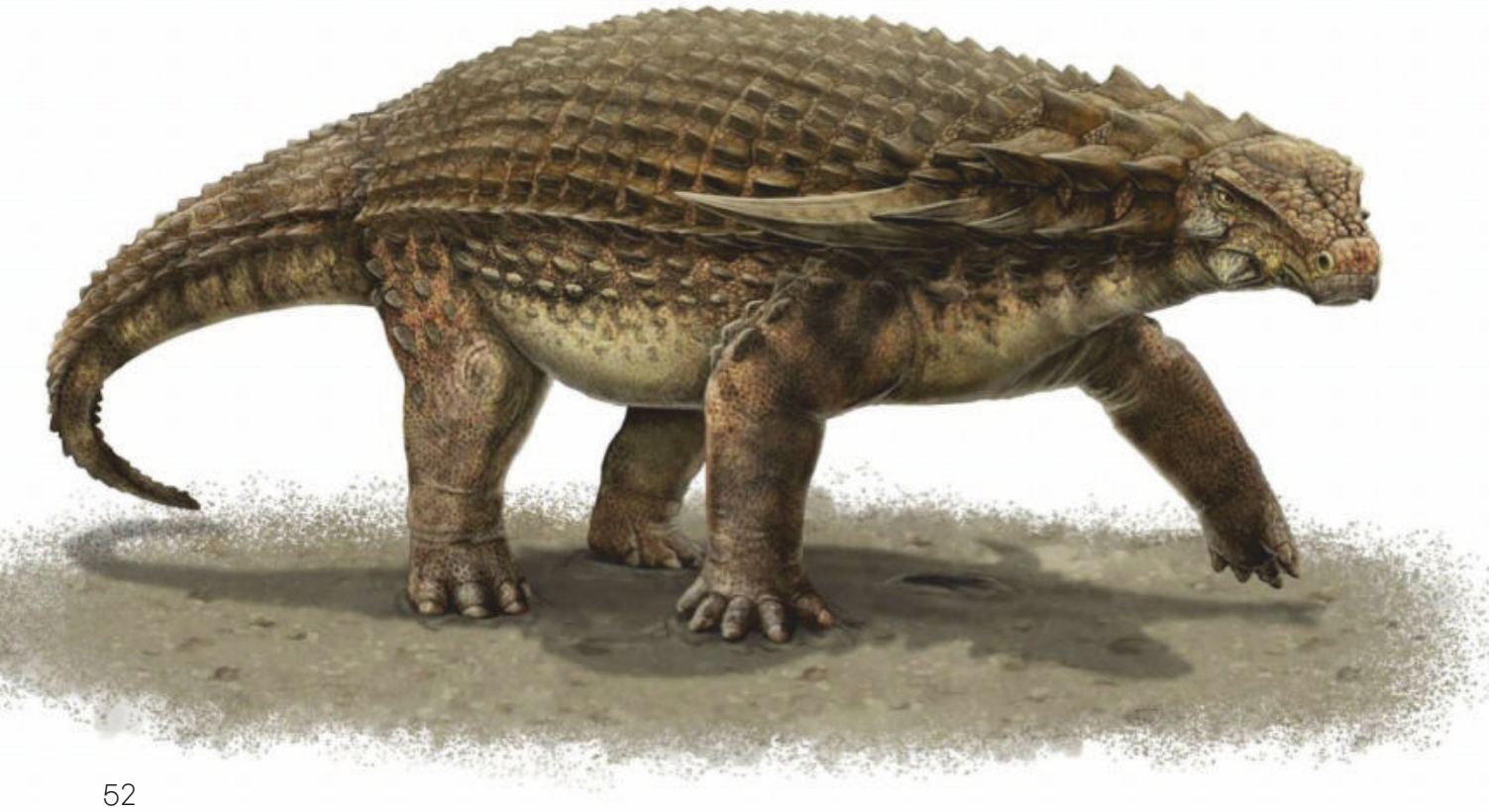


Anchiornis huxleyi

Length: 40cm, with a 50cm wingspan
Weight: 250g
Lived: Northeastern China, late-Jurassic (160 million years ago)

Crow-sized, four-winged flying dinosaur.

Similar to four-winged *Microraptor*, *Anchiornis* is known from hundreds of fossil specimens, meaning that it's well understood as a species.



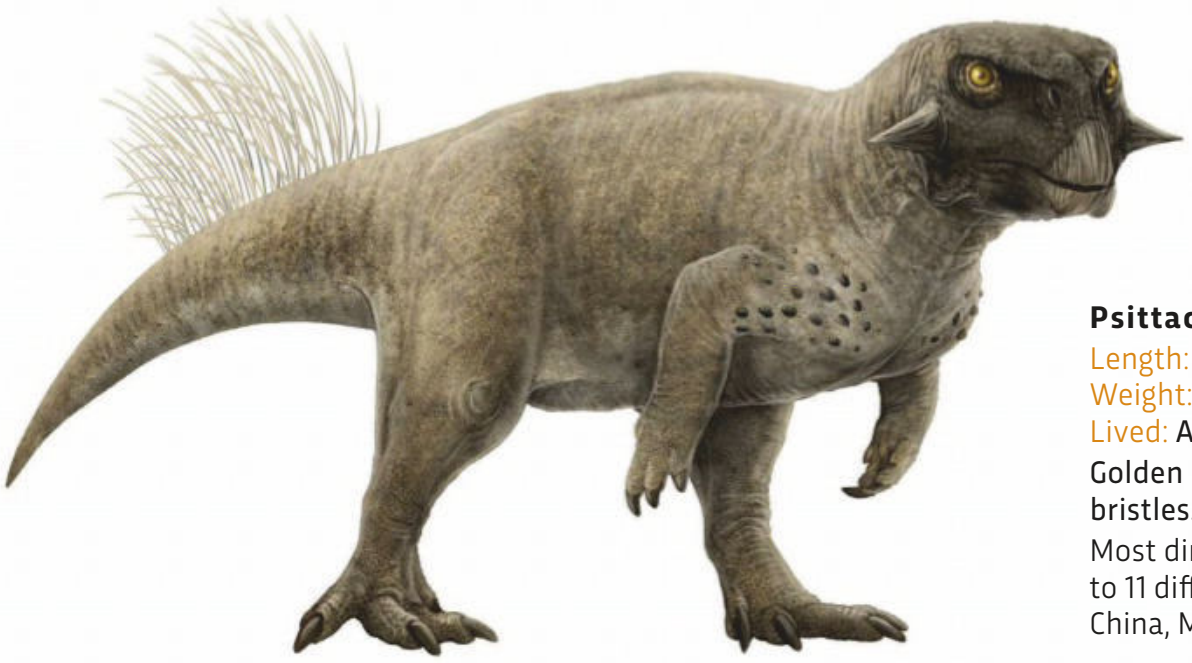
Borealopelta markmitchelli

Length: 5.5m
Weight: 1.3 tonnes
Lived: Western Canada, mid-Cretaceous (110 million years ago)

A type of heavily armoured ankylosaur, known as a nodosaur.

Ankylosaurs are typically thought to have had spikes and armour plates for defence, but *Borealopelta* may also have used its exaggerated spines to impress possible mates.

Archaeopteryx lithographica
Length: Up to 50cm, with a 50cm wingspan
Weight: 1kg
Lived: Southern Germany, late-Jurassic (150 million years ago)
Small flying carnivore, often regarded as the earliest known bird.
Unlike modern birds, *Archaeopteryx* didn't have a bony breastbone for large flight muscles to attach to, so was likely a much weaker flier.



Psittacosaurus sp.
Length: 1-2m
Weight: 20kg or more
Lived: Asia, mid-Cretaceous (110 million years ago)
Golden retriever-sized herbivore with long tail bristles. Walked on its two hind legs.
Most dinosaur genera have only one species, but up to 11 different kinds of *Psittacosaurus* are known from China, Mongolia, Siberia and Thailand.

Caihong juji
Length: 40cm
Weight: 500g
Lived: Northeastern China, late-Jurassic (160 million years ago)
Duck-sized, gliding carnivore covered in feathers.
This dinosaur's name means 'rainbow with the big crest' in Mandarin. It's since been suggested that what appeared to be a head crest may have been a small ridge above its eyes to avoid glare from the sunshine, as some eagles have today.

Sinosauropteryx prima
Length: Just over 1m
Weight: 550g
Lived: Northeastern China, early-Cretaceous (124 million years ago)
Slender, turkey-sized carnivore with a long tail.
Revealed to the world in 1996, *Sinosauropteryx* was the first dinosaur ever confirmed to have feathers.

ILLUSTRATIONS: GABRIEL UGUETO

"INTRIGUINGLY, ALL OF THESE MORE BRIGHTLY COLOURED DINOSAURS LIVED IN THE TREES"

Dr Maria McNamara was part of the team that found evidence of feathers and melanosomes in pterosaurs

a russet head-crest on the crow-sized, four-winged, flying dinosaur *Anchiornis*.

These discoveries relied on a method developed in part by Vinther for determining the colour of dinosaur and prehistoric bird feathers, not based on chemical traces of the melanin pigment (as with *Borealopelta*), but on the shape of fossilised microstructures in the feathers called melanosomes.

These tiny, durable structures are packages of melanin that are also found in the feathers of modern birds, and the hair and fur of mammals. Conveniently for palaeontologists, the shape of the melanosomes in modern animals tends to correlate to their colourings. Reddish phaeomelanin, for example, is typically found in melanosomes that are round and 400-500 nanometres wide. Black or brown 'eumelanin' is packaged in 300nm sausage-shaped melanosomes. This means that, even though little actual melanin remains in many of these fossils, researchers are still able to study the melanosomes and make reasonable guesses about the colour of these dinosaurs.

Using these techniques, we now know that early bird *Archaeopteryx* was black and white. *Microraptor*, the four-winged dinosaur from China, has melanosomes that suggest not only a blue-black colouration, but also a beautiful sheen, similar to a Eurasian magpie or a crow. The duck-sized *Caihong* was potentially even more stunning, with the colourful iridescence seen in modern hummingbirds (see 'How it works: Colouring in a dinosaur').

The intriguing thing about all of these more brightly coloured dinosaurs is that they lived in the trees. "If you live in more shaded environments then you're less exposed, both as predator and prey, and can become more colourful," says Vinther. So, in these animals, bright colours may have been used in sexual displays to attract mates and intimidate rivals.

On the ground, however, it was a different story. Dinosaurs such as *Sinosauropteryx*, *Borealopelta* and *Psittacosaurus* would have been more exposed and vulnerable, so their colouring was more camouflaged and drab, Vinther argues. It's likely that their dinosaur predators would have had excellent vision. Modern birds (the descendants of the dinosaurs) have some of the best eyesight in the animal kingdom, and can see ultraviolet light on top of all the colours that we see.

"You really had to be well camouflaged to stay alive, and camouflage strategies had to be more precise," says Vinther, explaining why countershading may prove to be the norm for all but the largest and scariest ground-dwelling dinosaurs. This countershading was probably patterned – rather than the uniform greys, greens and browns that dinosaurs historically

COLOURFUL EGGS
A CRACKING DISCOVERY

IT'S NOT JUST DINOSAUR FEATHERS AND SKIN THAT WERE COLOURED

Last year, researchers led by Jasmina Wiemann at Yale University in the US made an unexpected find: the eggshell colour of 15 species of dinosaurs and prehistoric birds.

Wiemann first found evidence of dinosaur egg colouration in 2017, using a chemical analysis to detect traces of two modern bird egg pigments (blue-green biliverdin and red-brown protoporphyrin) in fossil eggs of the dinosaur *Heyuannia huangi*. Then in 2018, she expanded the work to more species, this time using Raman microspectroscopy, which bounces a laser off fossils to reveal their molecular make-up. This uncovered pigments in the eggs of a number of theropod dinosaurs, including a relative of *Velociraptor* called *Deinonychus* (blue-green eggshells); small, bird-like carnivores called *Troodontids* (blue-green, beige or white); and the *Heyuannia huangi* (deep blue-green). Speckling was also detected on many of the eggs.

The discovery is "important because it tells us something about ecological interactions," Wiemann says. "Egg colours are tightly correlated with various nesting behaviours [in living birds]." Tinted shells likely camouflaged dinosaur eggs from predators, while species-specific speckling may have helped parents to differentiate their eggs from those of dinosaurs that were cuckoo-like nest parasites.

JOHN SHEEHAN, JASMINA WIEMANN/YALE UNIVERSITY

sported in illustrations. It's unlikely that any of these beasts were truly vibrant, however.

"I don't think there was ever a purple or pink dinosaur that walked on the ground," Vinther says. A psychedelic dinosaur wouldn't last long in a world filled with predators.

MISSING PIECES

The field of dinosaur colour is not without its controversies. Some experts have cautioned that the research might be reading the melanosome evidence too literally, missing out on other details that could affect a dinosaur's colouration.

Dr Maria McNamara is a palaeobiologist and expert on fossil colour at University College Cork in Ireland who, in 2018, was part of a team that found definitive evidence of downy feathers and melanosomes in pterosaurs, the flying reptilian contemporaries of the dinosaurs. She cautions that many kinds of bright colours in birds today are actually created by organic 'carotenoid' pigments, which rarely get preserved in fossils.

The colours of feathered dinosaurs elucidated so far "are a fair reconstruction of the melanin-based pigmentation," she says, "but that may have no relationship to the actual colour of those animals. It does nothing for the science if we produce beautiful coloured fluffy dinosaur reconstructions and then have to retract them."

Vinther agrees that carotenoid pigments are a gap in our knowledge, but points out that while carotenoids colour the feathers of about 40 per cent of songbirds (the dominant group of birds today), they only colour the feathers of 13 per cent of other birds. As such carotenoids were likely less important during the time of the dinosaurs, before songbirds evolved.

Vinther and others are trying to find fossil hints or traces of new kinds of colour-creating structures and pigments, including carotenoids. Whatever they find, though, all the experts agree that there are exciting times ahead.

"It goes much further than 'what colour is this dinosaur?'," says McNamara. "It can actually tell us the evolutionary driving forces there were at stake… Were the visual signalling strategies we see today already in place, or did dinosaurs communicate in novel ways?"

Prof Mike Benton, who led the work to reveal the colour of *Sinosauropteryx*, concurs: "The best thing about the whole 10 years of colour research in dinosaurs is that it has pushed back the field of speculation several notches – we can determine colours and patterns now, and we can begin to think about behaviour."

Every dinosaur fossil that palaeontologists unearth over the coming years will be a new story waiting to be told. Now it seems that we're finally beginning to read these stories in all their technicolour glory. SF

by **JOHN PICKRELL**
(@john_pickrell)
John is a Sydney-based science writer and author of the books Flying Dinosaurs *and* Weird Dinosaurs.

The Next Generation

Five years on from the launch of the award-winning Mu-so, Naim has redesigned and re-engineered its premium wireless speaker to make you rethink what's possible from a one-box system

OTHER GRILLE COLOURS AVAILABLE

Attention to detail, that's what separates the Mu-so from other wireless systems. Naim's experience of 45 years in the Hi-Fi industry has taught the company how to navigate the ebb and flow of technology trends and build timeless products: the kind that look as new, sound as impressive and work as effortlessly as the day they were bought. The only way to create tech like this is to obsess over the details that matter.

That's why 25 Naim engineers – electronic, industrial, acoustic and mechanical – spent three years creating the Mu-so 2nd Generation's new music streaming platform. It's the same tech powering the wireless capabilities in the company's £20,000 flagship audio player. The system has been built to deliver the convenience of streaming, without undermining the authenticity of the sound, whether you're listening to playlists from your phone, tuning in to internet radio from around the world or diving into your own album collection.

This new streaming platform is built into a refined speaker cabinet design that allows for a bigger sound, 13 per cent bigger, to be precise. Meanwhile new, additional precision speaker drivers have been added to the system to provide extra layers of detail to your audio. This combination means you get a bigger but more accurate bass delivery. All this is powered by Naim's new, multicore digital signal processor, which provides 2000 MIPS (Million Instructions Per Second), over 10 times more than the original Mu-so. In the end, Naim has re-engineered 95% of the speaker to make sure that customers can hear the difference over the award-winning first generation speaker.

On top of the acoustic upgrade, the new Mu-so has been furnished with the technology needed to be futureproof. As well as new ports, intuitive controls and upgraded Wi-Fi, the Mu-so comes with native support for AirPlay 2, TIDAL, Spotify Connect and Chromecast built-in, and if Naim's track record is anything to go by, there'll be future updates to meet its customers' needs.

BOOSTED TV SOUND

The all-new HDMI ARC input means you can simply connect the Mu-so to your TV via HDMI. Once they're linked you can control both with a single remote and if you have several devices, like set-top boxes and games consoles, it'll reduce the number of wires you need.

MULTIROOM READY

Now with Apple Home and Google Home compatibility, the Mu-so can collaborate with a network of speakers around the house. Better still, team it up with other Naim products (including the previous generation Mu-so and Mu-so Qb) via the upgraded Naim App.

STREAMING REFINED

Chromecast is built into the new Mu-so, giving you seamless access to a universe of services including Deezer, Qobuz and Tune In. There's also Spotify and TIDAL support on-board, so you can play music and control your Mu-so directly from your streaming App.

INTELLIGENT CONTROL

The minimalist interface has been upgraded. A proximity sensor wakes up the touch-sensitive panel as you approach – very space age – and from there you can tap to resume your Spotify playlist or go straight to your favourites.

DISCOVER MORE ABOUT THE MU-SO 2ND GENERATION AT **NAIMAUDIO.COM**

naim

WHAT DOES IT MEAN TO BE A MAN?

In the past few years, traditional male stereotypes have come under increasing scrutiny. Psychologist Gary Barker tells Helen Glenny why these stereotypes are harmful, and what a new, progressive form of masculinity could look like

Gary Barker

Gary Barker has a PhD in developmental psychology. He studies how we raise and socialise boys and men. He researches what factors cause men to gravitate into harmful behaviours, or more healthy, supportive, non-violent ideas about manhood. In the late 1990s he founded Promundo, which carries out global research into men, boys and masculinities. Promundo uses its findings and data to inform evidence-based programming and advocacy.

WHAT STARTED YOUR INTEREST IN THIS AREA?

I witnessed a school shooting in my high school in Houston, Texas, and saw negative views around masculinity in a place that was supposed to be safe to me. Ironically, it felt safer for me to talk about masculinity in some violent parts of Latin America – where I have family ties – than it did in my own high school. I went on to study for a PhD in developmental psychology, and in 1997 I started Promundo in Brazil, which came out of a close conversation with women's and children's rights activists. We realised that we could only get so far with women's rights without engaging men, too, which led us to start looking at men's views on gender equality and masculinity.

"THESE IDEAS ARE ASSOCIATED WITH HARMFUL BEHAVIOURS LIKE BINGE-DRINKING, SUICIDE, BULLYING..."

THE TERM 'TOXIC MASCULINITY' KEEPS CROPPING UP. WHAT DOES IT MEAN?

It's the shorthand to refer to restrictive ideas of manhood, like if somebody threatens my honour, I'd better use violence to win it back. Or if I need help or I feel vulnerable, I don't tell anybody about it. Or the idea that we're emotionally suppressed, don't emotionally connect to others, and that we're inherently in charge. All these things, we've clustered together and called 'toxic masculinities'. We've tended to avoid that term more recently. While it's a useful shorthand to those of us in progressive spaces, it immediately turns off many of the men who most need that conversation. We say 'toxic masculinity' and they hear 'you think men are inherently bad'. The activist Paul Kivel came up with the term 'the man box' to refer to this set of restrictive ideas [because they keep men stuck within a 'box' of how they think they should behave]. We've been using that term more, as it's more colloquial and doesn't feel so anti-men.

WHY ARE THESE IDEAS HARMFUL?

That so many men in the world continue to believe these ideas is harmful at face value. But we can also look at how these ideas are associated with harmful behaviours and outcomes like binge-drinking, suicide, bullying, sexual violence, harassment, sexual health, substance use, traffic accidents. We find a strong association everywhere we look ➤

– the more you believe in these restrictive ideas about masculinity, the more likely you are to carry out those behaviours. So it matters tremendously in terms of how men act in their daily life, and in the harm they cause to others. We all pay for it in terms of health services and other negative outcomes.

IN WHAT WAY?

There are lots of other factors in there, but if these restrictive norms of masculinity didn't exist, we've estimated that the UK economy would have an additional $3.8bn annually, and that's only looking at young men aged 18-30. These costs come from the amount of traffic accidents, suicide, bullying, depression, sexual violence and binge drinking that you can attribute to harmful masculinities. We look at how much each of those six factors cost in terms of hospitalisation, lost life, lost productivity and work. It's a rough calculation based on health economics analysis, but we think it gives an illustration of how these things are real.

WHAT'S 'GOOD' MASCULINITY, AND WHAT'S 'BAD' MASCULINITY?

In most of the world, if we ask a group of men 'what do you think a good man is?', they say things like honour, being true to your word, protecting and providing for those who depend on you. Sometimes the same men will hold these more positive views alongside the negative ones.

Research is showing just how much masculinity is performed. We can think people are judging us based on our versions of manhood. Look at the man who might pick a fight in a bar, then watch him when he gets home with his two-year-old daughter. He might be capable of tremendous connection, care and support for that vulnerable person, but push him up against a wall in a bar and he'll feel like, 'The only thing I can do to keep my manhood before the men who are watching me here is to pick up the bar stool or whatever else and use it.'

HOW CAN MEN RECOGNISE TOXIC MASCULINITY IN THEMSELVES?

What we do in group education spaces is try to show other ways of being a man. We might talk about how sometimes we lose our temper, or feel like we've got to talk over people. And we can talk about where that comes from. Maybe you saw some of that with your own father, or perhaps your own mother even reinforced that. It's starting with the belief that more men do want to tap into what they feel is their good side.

We'll then think about a moment when you've been bullied, you have bullied, or you stood there in silence when you saw somebody else bullied, even though you knew inside that the right thing to do was to speak out. For example, think about that woman who was belittled in a meeting, and you felt you couldn't speak out because none of the other men in the room did. Or that party where you saw the way that a group of guys were treating a woman who'd had a few too many drinks. You kind of knew what they would say if you stepped in, so you

"AS MEN EMBRACE THE THINGS THAT FEMINISM AND GENDER EQUALITY HAVE BROUGHT ON, WE GET TO BE HAPPIER, HEALTHIER AND MORE OPEN-HEARTED"

ILLUSTRATOR: EMMANUEL POLANCO

didn't. It's helping guys go through those scripts that all of us have seen and getting them to say, 'What could I do differently? And what was it that suppressed me from being the better man, the better person that I would have wanted to be?'

WHAT SORT OF EVIDENCE-BASED SOLUTIONS DO WE HAVE THAT CAN TACKLE THE PROBLEM?

We've got lots of evidence around group education: getting young men and adults in schools, sports clubs and workplaces to have critical discussions around masculinity. We've consistently found that this can drive lasting changes in attitudes and behaviours. Bystander interventions also work: training men to speak up when they see something that's potentially harmful, whether that's on a college campus, in school, at work. If you can get men to start doing this, then more will think that they should be speaking up, too.

We also have some growing evidence that changing the [social] structures around men can help. So, for example, with prenatal or antenatal visits, we can make the space available for men to be involved with their pregnant female partner, and then encourage them to come back for a follow-up visit for their own health needs. We've found that we get high percentages of men who will come back to that, more than almost any educational effort we've tried.

Our biggest challenge has been scaling up these promising initiatives to a big enough reach, so we actually see the needle beginning to shift, and we've got more guys speaking up, promoting equality, questioning harassment, and believing in healthy masculinity rather than toxic versions.

DO YOU THINK THE INTERNET IS MAKING THINGS WORSE? 'INCELS' [INVOLUNTARY CELIBATES] ARE KNOWN TO EXPRESS THESE NEGATIVE VIEWS AROUND MASCULINITY...

The internet is a space where you can be rude or socially unacceptable in a way that you wouldn't in another setting. There's a lack of social control, where you can say things without consequences. So all the things we've been doing in the physical, face-to-face world, we need to figure out how to do it in the virtual world, too. It's got to be a space where we're promoting positive behaviour – where we have guys saying, 'Dude, that's not okay'.

But as I mentioned before, masculinity is a performance. There might not be as many guys out there with misogynous views as we think. Research shows that if you think lots of other people around you believe something, you're more likely to act based on what you think they believe, and so the voices of the few get amplified. The question is how do we come up with a more thoughtful analysis of just how true some narratives of the internet might be. In the meantime, we need to oblige the biggest [social media] platforms to do more to call out cyberbullying and misogyny online. It's slowly happening, but not nearly as much as it needs to.

WHAT'S THE END GOAL HERE?

It's about equality and equity. As men embrace the things that feminism and gender equality have brought on, we get to be happier, healthier and more open-hearted human beings who have better intimate lives and better connections with others.

This is a better way of living, when the human beings around us are not afraid of us but see us as carers and caregiving, respectful, supportive and equitable. It doesn't take deep science to figure out that our lives get better as men when we buy into that version of manhood, and we become better human beings for it. SF

DISCOVER MORE

ON THE PODCAST

You can listen to our full interview with Gary in an upcoming episode of the Science Focus *podcast* ***sciencefocus.com/science-focus-podcast***

SPECIAL OFFER FOR BBC Science Focus MAGAZINE READERS

~~£66~~ NOW £33

SAVE 50%*

plus claim your FREE DIGITAL EDITION

To celebrate the 50th anniversary of Apollo 11 and humanity's first footsteps on the Moon, enjoy 50% off a year's subscription to *BBC Sky at Night Magazine* as well as a FREE digital edition of the magazine today!

NASA

CLAIM YOUR FREE DIGITAL EDITION

AND SAVE 50% OFF A YEAR'S SUBSCRIPTION TO *BBC SKY AT NIGHT MAGAZINE* NOW!

CALL 03330 162 119† and quote 'FOAPP19'

VISIT www.buysubscriptions.com/FOAPP19

*50% saving is only available to UK residents. Your subscription will start with the next available issue. The magazine issues shown have been displayed for illustration purposes. Information on how to receive your free digital edition will be emailed to the address provide when you sign up. This offer closes on 31st August 2018.

†UK calls will cost the same as other standard fixed line numbers (starting 01 or 02) and are included as part of any inclusive or free minutes allowances (if offered by your phone tariff). Outside of free call packages call charges from mobile phones will cost between 3p and 55p per minute. Lines are open Mon to Fri 8am – 6pm and Sat 9am – 1pm.

COMMENT

AN EGGCELLENT BREAKFAST

Eggs aren't as bad as we've been led to believe, despite what the headlines say

Recently, I saw a newspaper headline which claimed that 'Eating Just Three Eggs a Week Raises Risk of Heart Disease and Early Death'. These headlines were based on a study published in the journal *JAMA* where researchers followed 29,000 Americans who had filled in food questionnaires decades ago. Over that time quite a few had died. When the researchers compared the food questionnaires with what happened to those people, they concluded that eating an extra half-egg a day increased the risk of developing heart disease by 6 per cent.

As someone who eats eggs most mornings, am I worried by these findings? Not at all. Here are the reasons why.

First of all, the old idea that eggs are bad for you because they contain cholesterol is now widely recognised as a myth. The cholesterol that you eat has almost no effect on your blood cholesterol levels (most of the cholesterol in your body is produced by your liver). Second, a major weakness of this particular study was the fact that they collected data about people's egg-eating habits only once, at the start of the study. The group was followed for an average of 17 years and it is wildly unlikely that during that time they kept to the same sort of diet.

"The cholesterol that you eat has almost no effect on your blood cholesterol levels"

But perhaps, most importantly, we know that the findings of this study are flatly contradicted by the results of other, bigger studies.

First, there's the Nurses' Health and Health Professionals' Study, which involved more than 118,000 people. This research found no link between eggs and risk of heart disease or death. An even bigger study, involving more than 3,000,000 adults, published in the *British Medical Journal* a couple of years ago, came to exactly the same conclusion. This is why the NHS says, "There is no recommended limit on how many eggs people should eat."

A big study from China, involving over 500,000 people, was recently published in the journal *Heart*. Reassuringly, it found that people who eat eggs every day have an 18 per cent lower risk of dying from heart disease and a 28 per cent lower risk of dying from stroke than people who never eat eggs.

Eggs are a great source of protein (which will fill you up) and contain small amounts of almost every vitamin and mineral required by the human body. A single egg has decent amounts of vitamin B12, vitamin B2 (riboflavin), vitamin A and selenium.

Eggs are also low in calories (around 80 calories an egg). Whether you boil them, scramble them, or whisk up an omelette, they are a cracking way to start the day. SF

MICHAEL MOSLEY

Michael is a writer and broadcaster, who presents *Trust Me, I'm A Doctor*. His latest book is *The Fast 800* (£8.99, Short Books).

BBC TWO

PORTRAIT: KATE COPELAND ILLUSTRATION: MAXIM USIK

COMMENT

OPEN YOUR EYES

Could a fancy pair of glasses improve our relationship with the digital world?

There is a famous fight scene in John Carpenter's iconic 1980s cult sci-fi film *They Live* that has to be the most over-egged conflict ever put to celluloid. The main character is a working-class guy called Nada, who is deeply frustrated by the injustice of being kept down by the white-collar workers who brush past him on their way to their daily grind. One day, he discovers a pair of black sunglasses, puts them on and sees the world as it truly is: not in beautiful technicolour, but drab black and white, with billboards everywhere that are not advertising aspirational images, but words like 'MARRY AND REPRODUCE', 'OBEY', and 'THIS IS YOUR GOD'. The sunglasses reveal a plot to control the masses. Behind the plot are some of the white-collar workers – they are not humans, but grotesque aliens.

This is when the fight comes in. Nada tries to convince his buddy, Frank, to try on the glasses and see the truth behind the facade. But Frank refuses. Like, really refuses. They spend 10 of the 94 minutes of the movie physically beating the heck out of one another. "Put on the glasses!" <PUNCH> "Take a look! Put 'em on!" <PUNCH>. Nada is truly the world's most persistent sunglasses salesman.

I unabashedly love this film. It represents the length we will go to ignore the fact that we are being sold desires and lifestyles that serve nobody except those who sell them. Nada desperately wants his friend to open his eyes. Frank stubbornly refuses to. They are both sides of us in our relationship with our technological world.

"We are being sold desires and lifestyles that serve nobody except those who sell them"

We have all been told a million times what the true price of free is. We *know* that our incredibly rich behavioural data is being sold by everyone who runs a web service to people who want to sell us stuff. It is written in black and white, but it's covered up by filters that drive us to produce identities that never cry, always have amazing holidays and constantly consume.

Some people, though, want us to put on the sunglasses. I'm usually one of them, often on news programmes explaining tech companies' loose interpretations of privacy. But as in Nada and Frank's epic screen fight, talk doesn't always hit home. Sometimes you have to force the glasses on.

Artist Ivan Cash's interpretation of this mission is to block out screens entirely. He recently released his first batch of 'IRL glasses' that turn most digital displays black. Added bonus: they are designed to look like the glasses in *They Live*. But like my incessant talking, they aren't the solution either. In the recent *Crutch* episode of *Digital Human* he says as much, describing the IRL glasses as a catalyst that he hopes will spark debate about the problem surrounding screens.

The Hollywood version of this story ends with the aliens being revealed to the rest of us. But in the real world version, we already know the aliens are there. And what happens after the credits roll? Well, that's our sequel to write. **SF**

PORTRAIT: KATE COPELAND ILLUSTRATION: JUANJO CASULL

ALEKS KROTOSKI

Aleks is a social psychologist, broadcaster and journalist. She presents *Digital Human*.

BBC RADIO 4 92–95 FM & 198 LW

bluedot

18.19.20.21 JULY 2019
JODRELL BANK
CHESHIRE

CELEBRATING 50 YEARS SINCE THE MOON LANDING WITH A WEEKEND OF MUSIC, SCIENCE AND COSMIC CULTURE

HELEN SHARMAN. JAMES BURKE
JIM AL-KHALILI. LIZ BONNIN
LIBBY JACKSON. DALLAS CAMPBELL
HELEN PANKHURST. TIM O'BRIEN
CLANGERS [50TH ANNIVERSARY SCREENING & Q&A]
WALLACE & GROMIT [WORKSHOPS & SCREENING]
TOM SHAKESPEARE. DAVE GOULSON. TERESA ANDERSON. STEPHEN WILKINS
ROBERT NEWMAN. FRANK COTTRELL-BOYCE. DELIA DERBYSHIRE DAY
SIMEON BARBER. KATHERINE JOY. SUE NELSON. DANIELLE GEORGE
JEFF FORSHAW. PAUL FOOT. KNIGHTMARE LIVE. ABANDOMAN. ELF LYONS
BOBBY SEAGULL. MOONWALKING: EXPLORING AFROFUTURISM
ANDREW O'NEILL. KEISHA THOMPSON: MAN ON THE MOON. SARAH CROWTHER
THE DARK ROOM. MATTHEW PALMER. FOXDOG STUDIOS. JOHN ROBINS
BEN TARGET. KIRI PRITCHARD-MCLEAN. JOHN LUKE ROBERTS
COSMIC SHAMBLES. IVO GRAHAM

WITH MUSIC ACROSS THE WEEKEND

KRAFTWERK 3-D. NEW ORDER. HOT CHIP
JON HOPKINS. THE HALLÉ
KATE TEMPEST
PLUS MUCH, MUCH MORE

FINAL WEEKEND AND DAY TICKETS AVAILABLE FROM
DISCOVERTHEBLUEDOT.COM

From the Fields · bruntwood · United Utilities · mixmag · Manchester Evening News · NewScientist

MEET THE HUMAN HIBERNATORS

DR JULES MONTAGUE Illustration EMMANUEL POLANCO

A rare brain disorder causes some people to sleep up to 20 hours a day for weeks at a stretch. **JULES MONTAGUE** investigates the condition that medical science has yet to explain

There are some young people who are lost to the world. They are locked in a state of slumber, consumed by sleep for 15 to 20 hours each day, sometimes more. Then they finally open their eyes, only to speak monosyllabically or in muddled sentences. In these windows of semi-wakefulness, they sometimes lash out if disturbed, or regress to infancy, clapping their hands and singing nursery rhymes. But soon, somnolence inevitably returns.

Eventually, the spell is broken – but by now, weeks or even months have passed. They awaken fully, usually remembering little or nothing of the time they've lost. But their journey isn't over. Another episode will almost certainly follow, on average three months later but often much sooner than that.

This is Kleine-Levin Syndrome (KLS), sometimes nicknamed 'Sleeping Beauty syndrome', which is a rare brain disorder that affects between two and five people in a million. Usually beginning in childhood and adolescence, the youngest reported patient was four years old.

Megan Firth from Oxfordshire, now an 18-year-old law student, developed KLS symptoms aged 13 and had nine episodes last year alone. The most distressing symptom for her isn't sleepiness; instead it's derealisation – a dream-like sense of detachment from her surroundings – that can last for days or weeks at a time. Derealisation affects over 90 per cent of KLS patients.

"That's the part I find most scary," she says. "It kind of feels like you're in a bubble and I find it quite hard to tell the difference between what's real and what I dreamt." Others report a similar sense of estrangement from their environment or from themselves – they count their fingers to convince themselves of their existence, or fail to recognise their own reflection. They cannot feel water, even as they watch it drip onto their skin, despite it being hot enough to scald. They see a speaker's mouth move but hear their words out of sync, like they're watching a badly dubbed movie. Correspondingly, brain scans in some patients show decreased activity in the regions that integrate auditory, visual, and sensory information.

Megan's mother, Emma, describes another typical KLS symptom during episodes: apathy. "She basically stops communicating with the world. She stops connecting with her friends by phone, she doesn't want to go out. We've a lot of photos of the family going around doing whatever they're doing ➤

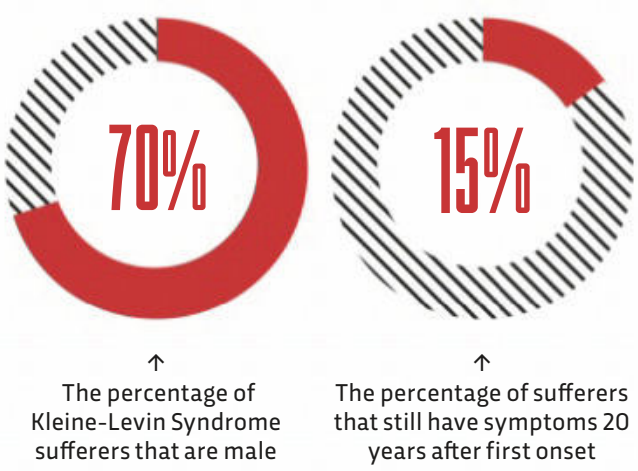
and in the background is Megan, fast asleep on a sofa."

Some patients become radically disinhibited, developing a voracious appetite for food. Two-thirds eat more – compulsively so, even stealing food or searching for it in dustbins. One drank several bottles of blackberry syrup each day. Another reported: "I would eat four or five peanut butter and jelly sandwiches – without even chewing – very fast, then would start to fall asleep again with food still in my mouth." Unsurprisingly rapid weight gain is a feature of KLS (an average of 4.6kg per episode, but even up to 13.5kg in some). Disinhibition can also declare itself through hypersexuality. Some masturbate in public ("to the point of bleeding", said one), expose themselves, or make unwanted sexual advances.

Repetitive compulsive behaviours also feature. "Megan used to watch box sets of *Charmed* and *Miranda* again and again, and films like *Love, Actually*," recalls Emma. "She actually wore out the *Charmed* box sets." One patient became a habitual fire-starter and another wrote continuously on the soles of his feet. Others pace relentlessly, rock back and forth or pull at their hair.

TRICKY DIAGNOSIS

Despite these classic features, getting a correct diagnosis is fraught with difficulty, as Megan discovered. For one thing, there's no specific test for KLS. Instead, it's identified by its symptoms; that means doctors have to know about it to diagnose it. Teenagers are often labelled as being lazy, or are accused of trying to avoid exams. A mental health misdiagnosis is common, since depression and anxiety are prevalent in KLS, even between episodes. There have been at least two reports of suicide, and 15 per cent of patients describe suicidal thoughts. Some experience paranoia that they're being watched or about to be



↑ The percentage of Kleine-Levin Syndrome sufferers that are male

↑ The percentage of sufferers that still have symptoms 20 years after first onset

eaten, or have hallucinations of snakes, bears and dead bodies, which leads to a misdiagnosis of schizophrenia.

A clinical sleep study, which records brain activity, blood oxygen levels, heart rate, breathing, and leg and eye movements during sleep, can support a diagnosis but cannot cement it. Functional brain imaging is usually limited to research settings and can be difficult to perform during KLS episodes, and may reveal nothing in any case (occasionally there is, however, decreased activity in the brain's temporal and frontal lobes, thalamus and hypothalamus).

"TWO-THIRDS EAT MORE, EVEN STEALING FOOD OR SEARCHING FOR IT IN DUSTBINS"

But if diagnosis is challenging, then understanding why KLS happens is even more so. There's a precipitating factor in 89 per cent of cases – such as a flu-like illness, tonsillitis, sleep deprivation, or alcohol. Researchers think these might trigger an autoimmune and/or inflammatory cascade of events. Dr Guy Leschziner, consultant neurologist and sleep expert at the Sleep Disorders Centre at Guy's and St Thomas' Hospital in London, sees some similarities between KLS and other neurological immune disorders.

"In a few cases, inflammation in the brain has been found, although it remains uncertain if these cases were KLS or another disorder causing similar features," he explains. "KLS remains a syndrome – a collection of clinical features – rather than a specific disease, and so we do not know if all patients have the same underlying cause. My own view is that some patients probably do have inflammation of the brain, while others have a channelopathy – a disorder of the ion channels that mediate electric impulses in the brain."

There's a genetic hypothesis, too, even though no specific 'KLS gene' has been identified so far and most cases are sporadic. All the same, up to 5 per cent of patients have an affected family member. We even know of two pairs of identical twins with KLS, and one family where a father, three sons and two daughters were affected. These genetic insights haven't yet, however, led to any new treatments.

NOT JUST LAZY

When an episode occurs, Megan knows she must simply wait for it to subside, which is especially demanding when it seems interminable: a third of patients experience at least one episode that lasts for more than a month. Families are advised to keep their children at home (unless significant psychiatric manifestations warrant hospitalisation) and encourage them to drink frequently, and go to the toilet regularly to avoid kidney and bladder damage.

Other people's perceptions of the disorder are particularly trying, says Emma. "Some have said really dumb things over the years, along the lines of 'teenagers are just lazy' or 'just tell her to wake up'. We often used to say ●

LIVING IN DREAMLAND

Megan Firth tells us about life with Kleine-Levin Syndrome

Megan, fast asleep during a KLS episode (left) and with her family (right)

Tell us about your first episode.

I was 13 years old. I was taken to hospital with suspected meningitis. We now know I had really bad flu, and that triggered the onset. I was in hospital for about five days and they ran all sorts of tests and couldn't find anything. They sent me home saying it was a one-off thing and nothing to worry about. But I was sleeping 18 hours a day for three weeks. It took another three weeks to recover.

How were you diagnosed?

Three months later I went to Australia. On the third day I couldn't wake up. I was admitted to the [Queensland] Children's Hospital in Brisbane. My mum was doing lots of research and came up with KLS at the same time the doctor said that they'd had an idea of what it could be. We saw a specialist who had seen it before. For me, that was when the fear factor of not knowing what was happening just stopped. [The diagnosis was later confirmed in the UK after a long series of consultations.]

What happens to your appetite?

During some episodes I lose it. But in Brisbane I remember them bringing me Vegemite sandwiches and thinking, "This is disgusting but I'm going to eat them anyway because I'm really hungry." I get cravings as I'm coming out of an episode. Tinned fruit is one of the main ones, which is weird because others go for chocolate cake and other nice stuff.

Are there any triggers?

Tiredness, alcohol (so I don't drink), flying, and if I get ill. When we go on family holidays we tend not to fly if we can avoid it. Most of the time, if we're staying in Europe, we drive there.

How do people react when you tell them you have KLS?

It's not something you can explain in 10 minutes. I have had people who told me that it sounds really nice to be sleeping all the time. I never say anything back. But most people at university have been really nice about it.

How does the future look?

I'm hoping by the time I finish university, my KLS will be a thing of the past. My teenage years have been quite difficult. I'm kind of hoping that I can have a normal 20s to make up for it!

PA REAL LIFE X2

that if Megan had a plaster cast on her leg, no one would say, 'can't you just tell her get up and walk?'. When you're struggling with a 14-year-old acting like a 6-year-old and wondering, 'what if this episode doesn't ever end?', that's really unhelpful."

There's no cure, despite doctors trialling hundreds of medications, electroconvulsive therapy, and even insulin-induced comas. Stimulants like modafanil can improve alertness, but they can also increase aggression and are ineffective against derealisation. Lithium could prevent episodes, but also has potential adverse side effects.

So why has a cure remained stubbornly out of reach? "We have no real inkling of the cause of KLS, which makes life very difficult," Leschziner explains. "The major reason, however, is its rarity. Getting sufficient numbers of patients into a randomised controlled trial to demonstrate a clear effect is nigh-on impossible," he adds.

"SOME HAVE SAID REALLY DUMB THINGS OVER THE YEARS, ALONG THE LINES OF 'TEENAGERS ARE JUST LAZY' OR 'TELL HER TO WAKE UP'"

It's also challenging to establish if a given treatment is truly what's helping a patient, since the episodes are unpredictable and a KLS spell might have faded without it.

French researchers recently treated 26 patients experiencing episodes exceeding 30 days with high-dose intravenous steroids, which dampen down innate immune and inflammatory responses. The steroids shortened sleeping episodes by up to 11 days in 42 per cent of patients. But this was a retrospective review, not a placebo-controlled randomised trial. Steroids also have significant risks, especially with frequent or prolonged use. Nonetheless, it's progress for a condition marked by a dearth of research since it was first described in 1862.

STAYING OPTIMISTIC

Megan remains hopeful for her future. KLS often dissipates over time: the median length of time to be afflicted with the disease is around 15 years, although some 15 per cent of sufferers remain affected even 20 years after onset.

Leschziner is also optimistic about the future of KLS research, referring to recent renewed scientific interest in understanding its genetic and biochemical changes. Some of this research is in its early stages. but maybe one day the spell of KLS will be lifted.

Emma says of her daughter: "Even before she had KLS, I'd like to think we have instilled in her that nothing is impossible." Perhaps, for Megan and many others, a future without KLS isn't impossible, either. **SF**

by **DR JULES MONTAGUE** *(@Jules_Montague) Jules is a consultant neurologist and freelance science writer. Her latest book is* Lost And Found *(£9.99, Sceptre).*

COOKING UP ALIEN ATMOSPHERES

Scientists are recreating the air that clings to distant worlds. Could their work help to reveal the presence of extraterrestrial life?

by PHILIP BALL

How do you spot an alien? Some scientists are looking for communication signals beamed out into space. Others propose looking for dips in starlight that might be caused by huge alien-built megastructures orbiting a distant sun.

But perhaps the most promising line of enquiry lies with probing the layer of gases surrounding alien worlds. If we were to watch Earth from afar, we would be able to infer our existence by analysing the make-up of our atmosphere. There's only one process we know of that could keep it so rich in oxygen: life.

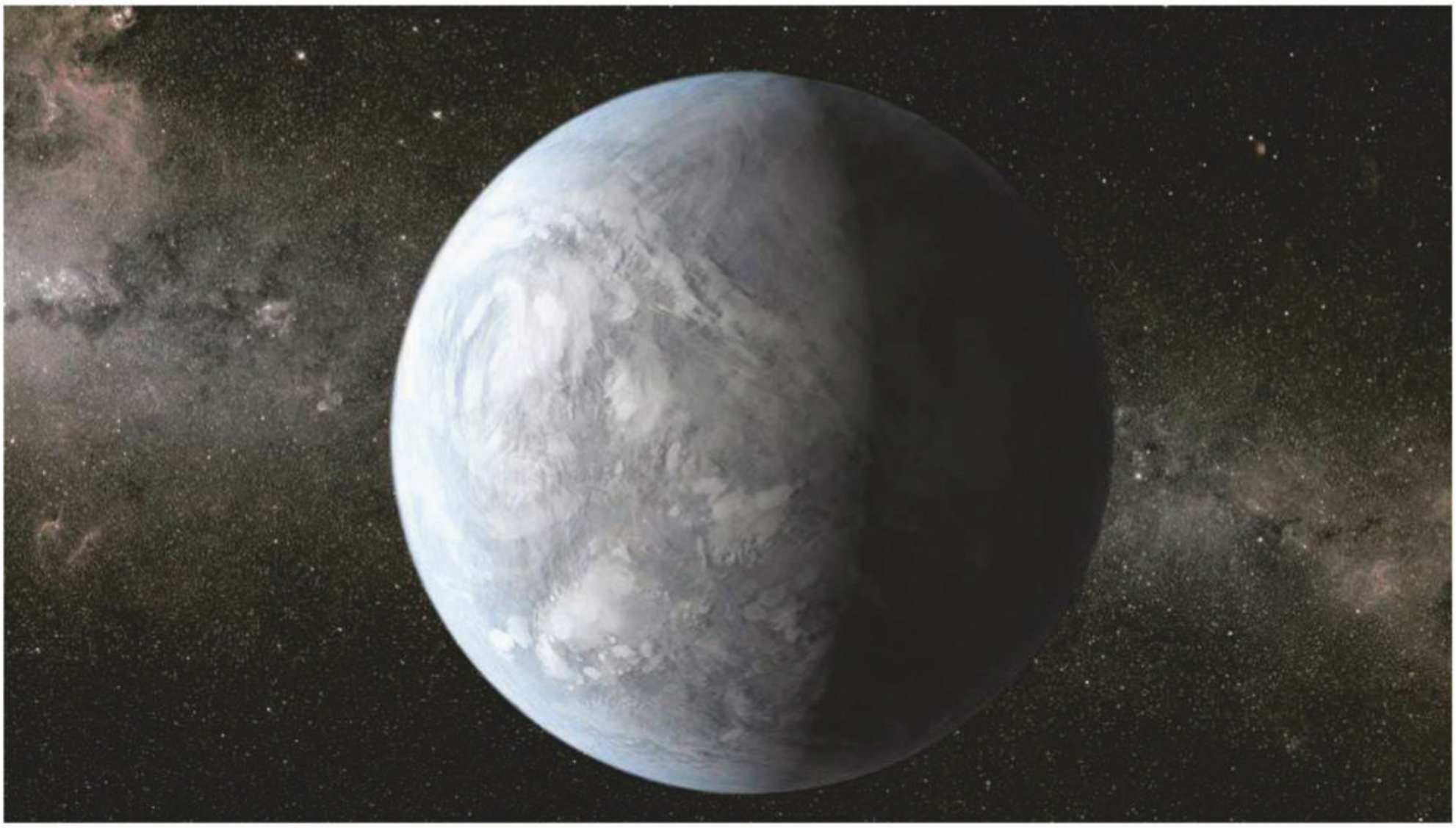
If aliens live on other worlds, they'd probably also imprint a signature of their existence in their atmospheres. While we are able to peer at alien atmospheres through the latest space telescopes, there's a catch: we don't really know what we're looking for. We only have Earth as a comparison – but what if there are other combinations of gases that can reveal the presence of life?

The answer to this question may lie in intriguing new research that's replicating alien air on Earth, cooking up exotic brews in laboratories. Meanwhile, other scientists are simulating the weather and circulation of alien atmospheres inside powerful supercomputers to find out just how hospitable distant worlds may be. This research is already providing some tantalising clues about where the next generation of alien hunters should be focusing their attention.

SOMETHING IN THE AIR

Since the first detection of an exoplanet – a planet around another star – in 1992, more than 4,000 have been identified, mostly by observing the subtle but regular dimming in starlight as the planet passes across its parent star and blocks some of its light (a transit). More than half of exoplanets were detected in this way by NASA's Kepler space telescope (active from 2009 to October 2018). In April 2018, NASA launched a successor to Kepler: the Transiting Exoplanet Survey Satellite (TESS).

GETTY IMAGES



ABOVE Super-Earths like Kepler 62e are a common type of exoplanet, with thick and misty atmospheres

RIGHT Dr Sarah Hörst and assistant research scientist Chao He examine a sample of simulated exoplanet atmosphere

In order to study an exoplanet's atmosphere, astronomers look at how the atmosphere absorbs the starlight passing through it. Different molecules of gas will absorb different wavelengths of light, so researchers can analyse the star's filtered light spectrum during a transit to pin down which gases are present. In this way, astronomers made the first direct detection and chemical analysis of an exoplanet atmosphere in 2001 – finding sodium in the atmosphere of a gas giant known as HD 209458 b.

Since then, several exoplanets have had their atmospheres analysed, revealing the presence of water vapour, methane, carbon dioxide, and even small amounts of oxygen around some of these worlds. None of these gases alone signals life, however – not even oxygen, as we know of processes that can create small amounts of it without involving living organisms.

This is where the work of planetary scientist Dr Sarah Hörst comes in. At Johns Hopkins University in Baltimore, US, she is leading a team of scientists who are brewing lab simulations of the gases likely to be in exoplanet atmospheres, in order to find out what they might produce. So far, Hörst's work has focused on an atmospheric phenomenon that'll be familiar to anyone who's spent time in a big city: haze.

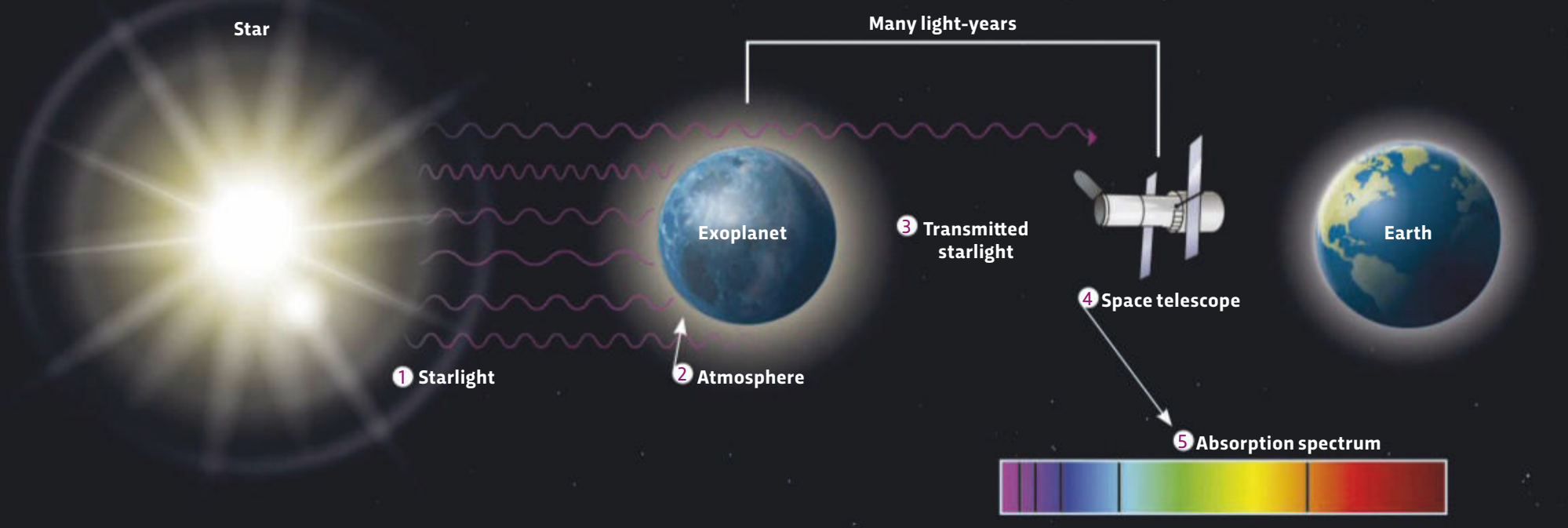
COOKING WITH GAS

The two most common types of exoplanet have no equivalent in our own Solar System. One is the 'super-Earth': rocky, with a diameter 1.25 to two times that of Earth. The other is the 'mini-Neptune': about two to four times the size of our planet, with a thick blanket of gases (mostly hydrogen and helium) over a dense core of rock or ice.

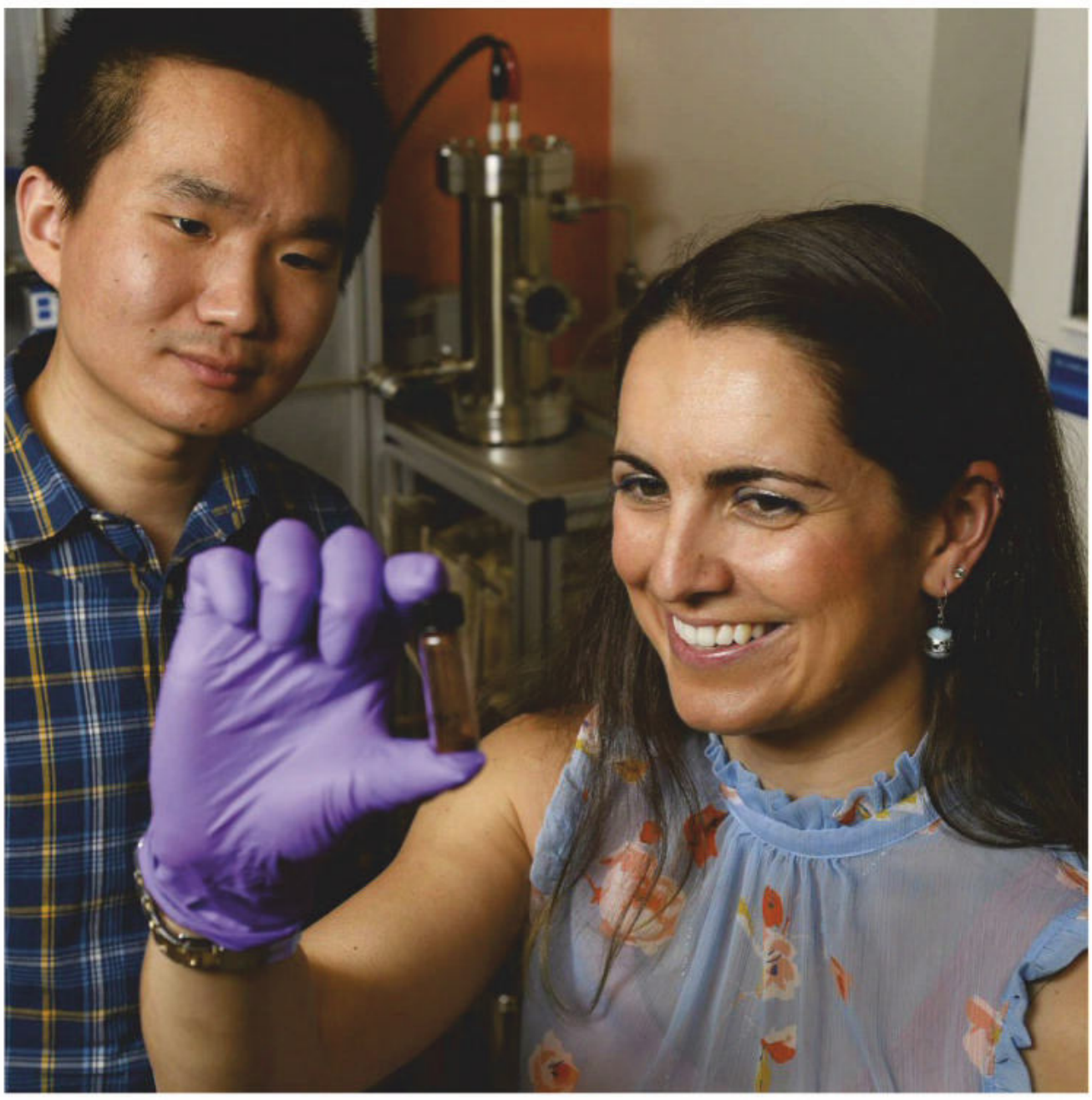
Astronomers have discovered that the atmospheres of super-Earths and mini-Neptunes are rather thick and misty: light doesn't get through them easily. This could be because they're full of clouds (perhaps made from droplets condensed from water vapour or other gases such as methane), or it might be due to haze: tiny, dust-like solid particles, like the pall over cities caused by traffic fumes. Hörst is trying to find out. She says that there might be ramifications for whether planets like this could support life. According to Hörst, haze particles in an atmosphere can have a huge impact on how starlight moves through it. "This can affect things like how much and what sort of energy is available at the surface of a planet for life, and what the temperature of the surface is," she says.

We have only the sketchiest information about the chemistry of these atmospheres, so Hörst carries out simulations for a wide range of possible compositions, including all the common gases likely to be found around worlds like these: water vapour, carbon monoxide, carbon dioxide, nitrogen, hydrogen, helium and methane. Hörst mixes up different proportions of these gases at temperatures between about 25°C and 325°C, mimicking the conditions thought to exist on super-Earths and mini-Neptunes.

HOW TO ANALYSE AN ALIEN ATMOSPHERE



1. The star's light is made up of many individual wavelengths
2. The starlight passes through the exoplanet's atmosphere
3. The atmosphere absorbs specific wavelengths of starlight, depending on which gas molecules are present – leaving a 'fingerprint' of those molecules in the transmitted light
4. During the exoplanet's 'transit' across its star, a space telescope such as the Hubble – or soon the James Webb Space Telescope – detects the filtered light and analyses its spectrum using a device called a spectrograph
5. Gaps in the star's spectrum indicate the presence of particular gas molecules in the planet's atmosphere



NASA, WILL KIRK/JHU ILLUSTRATION: ACUTE GRAPHICS

It's a kind of cosmic cookery: throw together the ingredients, bake at moderate heat, and see what comes out. There's another crucial ingredient, too: energy to kick off chemical reactions by breaking molecules apart. On exoplanets, this could come from high-energy ultraviolet rays in the starlight, or from electrically charged particles formed by cosmic rays flooding into the upper regions of the atmosphere. The researchers simulate these energy sources using either an ultraviolet lamp or an electrical discharge like that in a fluorescent lighting tube.

Most of the mixtures that Hörst and her team have studied generated brownish, smog-like haze, similar to what we see on Saturn's moon Titan. The amount of haze varied widely, though, depending on the composition of the mixture. For example, two of the experiments with plenty of water vapour and methane produced the most haze, but a third experiment also generated fine particles with no methane present at all.

More work is needed to find out what the detection of haze on a distant exoplanet would mean for the likelihood of finding life. Hörst says that in some cases haze might block harmful radiation (as the ozone layer ➲

"IT WON'T BE LONG BEFORE WE'RE ABLE TO STUDY THE ATMOSPHERES OF EVER MORE EXOTIC EXOPLANETS"

does on Earth), but it could also lead to cooling of the surface and a lack of liquid water. "We need to know more about the planet and its atmosphere to be able to understand what the conditions might be like on the surface, and what processes would have led to the formation of haze," she says.

In the meantime, the holy grail of this area of research is to identify some molecule – or a set of molecules – that can exist only if there is life, i.e. a 'biosignature' of alien life. But what might that be?

The answer doesn't appear to be oxygen alone. Hörst and colleagues saw oxygen form in their simulation experiments, purely from chemical reactions induced by ultraviolet light. They also saw organic molecules like ethanol and formaldehyde, which rules these out as definite biosignatures, too. One possible biosignature is the simultaneous existence of ozone and methane, says Hörst. This is a chemically unstable blend of gases, and there's no known geological process that could sustain them. "It would be really hard to have them together in the same atmosphere without some source replenishing them," says Hörst. On Earth, the biosphere is ultimately the source of both of these gases in our atmosphere.

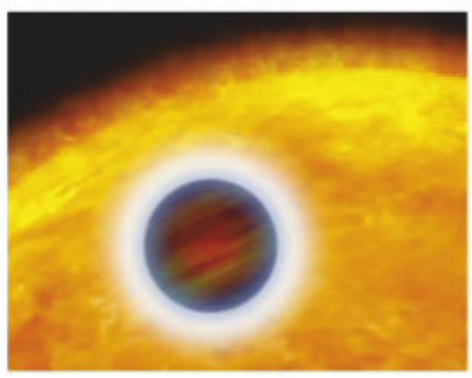
Some of the most enticing worlds to look for biosignatures such as these, Hörst feels, are the set of planets detected in 2015 around a dim star called TRAPPIST-1, located 40 light-years away in the constellation of Aquarius. Seven of the worlds orbiting this star are vaguely Earth-like, and most of them are potentially habitable, having the right conditions for liquid water on their surfaces. By looking at the light

WEIRD WEATHER

Think Earth's weather is unpredictable? Here are some of the strange phenomena we've spotted elsewhere in the Universe

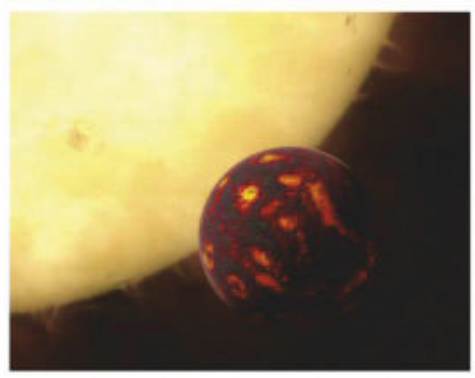
DIAMOND RAIN

The atmospheres of some gas giants contain plenty of carbon, created when lightning reacts with methane. At high pressures and temperatures inside the atmosphere, this might condense into crystals of diamond, some as big as blueberries. Experts estimate that, on Saturn, about 1,000 tonnes of diamonds are produced every year.



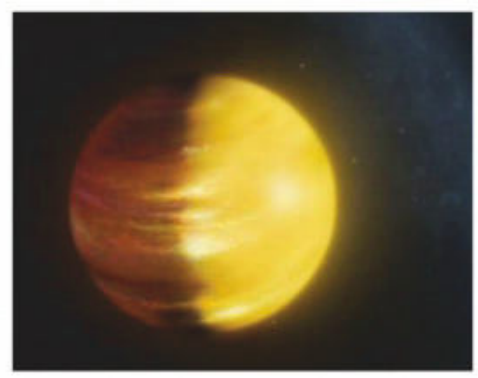
METAL MONSOON

The hot Jupiter HD 209458 b, also known as 'Osiris', has atmospheric temperatures of several thousand degrees. It's likely that rains of molten iron or silicate glass pelt down there, falling in wind speeds of several kilometres per second (compared to a mere 70 metres per second for severe hurricanes on Earth). The result is a lacerating blast of hot metal and rock.



INFERNAL STORM

55 Cancri e is a rocky planet about twice the diameter of the Earth that orbits so close to its star that its surface has a temperature of around 2,000°C. Molten lava spouts into the atmosphere to fall as fiery rain, and this turbulent, sooty atmosphere is filled with electrically charged particles, producing immense, planet-wide lightning storms.



GEMSTONE CLOUDS

HAT-P-7b, a hot Jupiter located 1,000 light-years away, has clouds on its cool, night side made of condensed aluminium oxide – the stuff that forms the basis of minerals like rubies and sapphires. Winds carry these clouds to the planet's hot day side, where temperatures of close to 2,000°C quickly destroy them.

NASA/JPL X2, ESA, SCIENCE PHOTO LIBRARY

RIGHT By studying their atmospheres, we can confirm if some of the planets surrounding the TRAPPIST-1 star have the right conditions for liquid water to exist

transmitted through their atmospheres, Hörst and coworkers have found that some of them may have clouds or haze, though it's hard to be more precise at this stage about which option is more likely.

Hörst thinks that these intriguing planets should be an early target for NASA's James Webb Space Telescope (JWST), the planned successor to the Hubble Space Telescope, which will take a closer look at exoplanet atmospheres once its been launched in 2021.

EXO-CLIMATES

Life on Earth relies not only on having the right kind of atmosphere, but also on the whole climate system: how air, oceans and heat circulate, and how clouds form. If we found an exoplanet with an identical atmospheric composition to Earth, it might still be inhospitable to life if it lacked a similar climate system. A new research area called 'exoclimatology' is aiming to understand exoplanet climates – and their implications for life – by applying the computer models used to simulate the Earth's weather and climate to other worlds.

So far, much of the work has focused on another common exoplanet type: 'hot Jupiters' – gas giants like our own Jupiter but which orbit much closer to their parent star. They tend to either rotate very slowly or be 'tidally locked' so that – as with the Moon orbiting the Earth – the same side always faces the star. This gives the planets a temperature difference between the 'day' side and the 'night' side which drives atmospheric circulation, much as the temperature difference between Earth's equator and the poles powers our own climate.

Computer models of this circulation indicate that hot Jupiters have a kind of atmospheric jet stream, says Dr Nathan Mayne, who leads the exoclimatology group at the University of Exeter. This can mix up the chemistry of the hot and cool sides of the atmosphere, changing the blend of gases in some places and thus the amount of starlight that's transmitted to the surface. While hot Jupiters are not likely to harbour life, this shows how the circulation of the atmosphere can play a crucial role in the surface conditions on a planet – with important implications for their habitability.

Add water to the equation and things get even more interesting. Some potentially habitable planets like the TRAPPIST-1 group are also likely to be tidally locked to their star. If these exoplanets have liquid water on their surface, then water on the hot day side will evaporate, eventually condensing into rain or snow on the cooler night side. "Land covering the day side would quickly dry out and the moisture would be transported to the night side," says Mayne. "But if there's an ocean, the water can circulate back" – creating a giant conveyor belt of water between the two sides of the planet. This could make the difference between a barren planet divided into halves – each too extreme for life to exist – and a planet where water circulation creates a more moist and clement environment.

With the latest generation of space telescopes, it won't be long before we're able to study the atmospheres of ever more exotic exoplanets. "The combination of TESS and the JWST should provide us with a lot of compelling worlds to study," says Hörst. Work by the likes of her and Mayne is set to become crucial to astronomers who want to know whether the exoplanet gases and weather patterns that they're detecting are the symptoms of a sterile planet, or maybe – just maybe – hints of life... **SF**

by **PHILIP BALL**

Philip is a freelance science writer, specialising in physics and maths

DISCOVER MORE

LISTEN

In this episode of The Curious Cases Of Rutherford & Fry, *find out if we'll ever discover alien life.*

bit.ly/find_alien_life

PART OF THE BBC Science Focus MAGAZINE COLLECTION

MAN ON THE MOON

50TH ANNIVERSARY

Celebrate the golden anniversary of the first Moon landing with this *BBC Science Focus Special Edition* and retrace the journey from the start of the space race to the moment Neil Armstrong took his historic small step

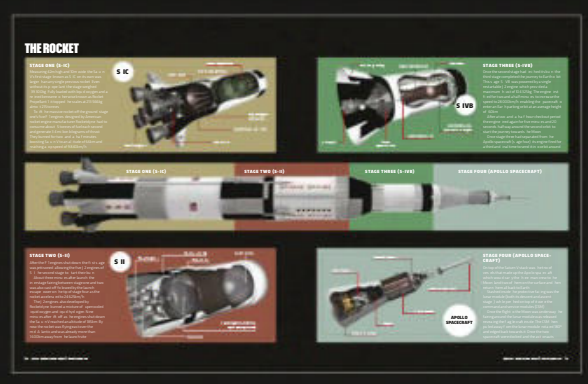
IN THIS ISSUE...

- How JFK inspired a nation to win the space race
- Meet the NASA rocket scientist with a dark past
- Neil Armstrong on his emergency lunar landing
- The women who were key to Apollo 11's success
- Experts explain why we should return to the Moon

PLUS – subscribers to *BBC Science Focus Magazine* receive FREE UK postage on this special edition

ONLY £9.99 INC. FREE UK POSTAGE*

How the two most powerful nations on Earth became locked in a race to the Moon



Explore the Saturn V rocket that blasted the Apollo 11 crew into space

Neil Armstrong describes what it was like to land on the Moon for the first time

Pre-order online
www.buysubscriptions.com/manonmoon

Or call 03330 162 138†
and quote Man on the Moon PRINT 1

†UK calls will cost the same as other standard fixed line numbers (starting 01 or 02) and are included as part of any inclusive or free minutes allowances (if offered by your phone tariff). Outside of free call packages, call charges from mobile phones will cost between 3p and 55p per minute. Lines are open Mon to Fri 8am-6pm and Sat 9am-1pm. *Subscribers to *BBC Science Focus Magazine* receive FREE UK POSTAGE on this special edition. Prices including postage are: £11.49 for all other UK residents, £12.99 for Europe and £13.49 for Rest of World. All orders subject to availability. Please allow up to 21 days for delivery.

Q&A

ALL YOUR QUESTIONS ANSWERED

THIS ISSUE'S EXPERTS

DR ALASTAIR GUNN
Astronomer, astrophysicist

ALEX FRANKLIN-CHEUNG
Environment/ climate expert

DR PETER J BENTLEY
Computer scientist, author

DR STEVE BRUSATTE
Palaeontologist, dinosaur expert

DR HILARY GUITE
Former GP, science writer

CHARLOTTE CORNEY
Zoo director, conservationist

DR HELEN SCALES
Oceans expert, science writer

DR CHRISTIAN JARRETT
Neuroscientist, science writer

DR EMMA DAVIES
Chemistry expert, science writer

LUIS VILLAZON
Science/tech writer

JULES HOWARD
Zoologist, science writer

PROF ROBERT MATTHEWS
Physicist, science writer

LARRY FITZGERALD, LONDON

WHY DO PHYSICISTS TALK ABOUT SYMMETRY SO MUCH?

Symmetry is something we usually think of as an aesthetic rather than a scientific concept – repeated patterns of tiles, for example. But in their quest to discover the basic laws of the Universe, physicists have found symmetry useful. That's because if something possesses symmetry, it means it can be altered in certain ways, and yet remain unchanged. For example, if a square is flipped over or rotated by 90°, it looks as if nothing has changed. Physicists believe that the laws of nature should be similarly 'invariant', applying equally well regardless of where in space and time they're used. Around a century ago, the German mathematician Emmy Noether showed that there's a deep connection between such symmetries and key concepts in physics like the laws of the conservation of energy and momentum. This has proved particularly useful to theorists trying to make sense of the subatomic world. *RM*

GETTY IMAGES

SHIRI, VIA EMAIL

CAN COINCIDENCES BE EXPLAINED BY SCIENCE?

Absolutely – it's all to do with probability. Pretty much any event or object in our lives has the power to generate coincidences. It's just that we don't notice the vast majority because they're boring – like seeing two blue cars parked next to each other. But every so often, we think we've encountered an incredibly rare coincidence. What we're forgetting is a basic rule of probability: that even rare events are sure to happen if given enough opportunities. It's often hard even to estimate the number of these, and thus it's impossible to gauge their true probability, leaving us feeling baffled and spooked.

But such estimates can be calculated for some coincidences. For example, probability theory shows there's almost a 50:50 chance of at least two of the 23 players in any football match (including the ref) having the same birthday (see right). Those chances increase dramatically if we're willing to be a bit flexible about what counts as a coincidence. For instance, if we allow birthdays within a day of each other to count, then the chances of witnessing at least one coincidence among any two football teams soars to around 90 per cent. This example involves random, independent variables (i.e. players' birthdays). If there's something linking the variables, the chances of coincidences get a boost.

Take the bizarre case of *The Wreck Of The Titan*, a novel about how the world's largest ocean liner sank when it hit an iceberg, resulting in many deaths because of a lack of lifeboats. Spookily, the book appeared 14 years before the real-life *Titanic* disaster of 1912. But there are reasons for the similarities: the threat of icebergs to giant liners and the provision of lifeboats were already concerns when this book was written. Moreover, such vast ships tend to be given grand names. In short, many of the 'coincidences' in the novel aren't independent, but are a direct consequence of its storyline. ***RM***

EXPLAINER: THE BIRTHDAY PARADOX

There's a 50 per cent chance that, in any group of 23 people, two people will share a birthday. First, we need to work out the probability that everyone in the group has a *unique* birthday.

Considering a 'group' of just one person, the chance is 100 per cent. If we add another person, there's just one birthday that they could share with person one, so their probability of having a unique birthday is 364/365. For person three, it's 363/365. And so on, until person 23, for whom the probability of a unique birthday is 343/365.

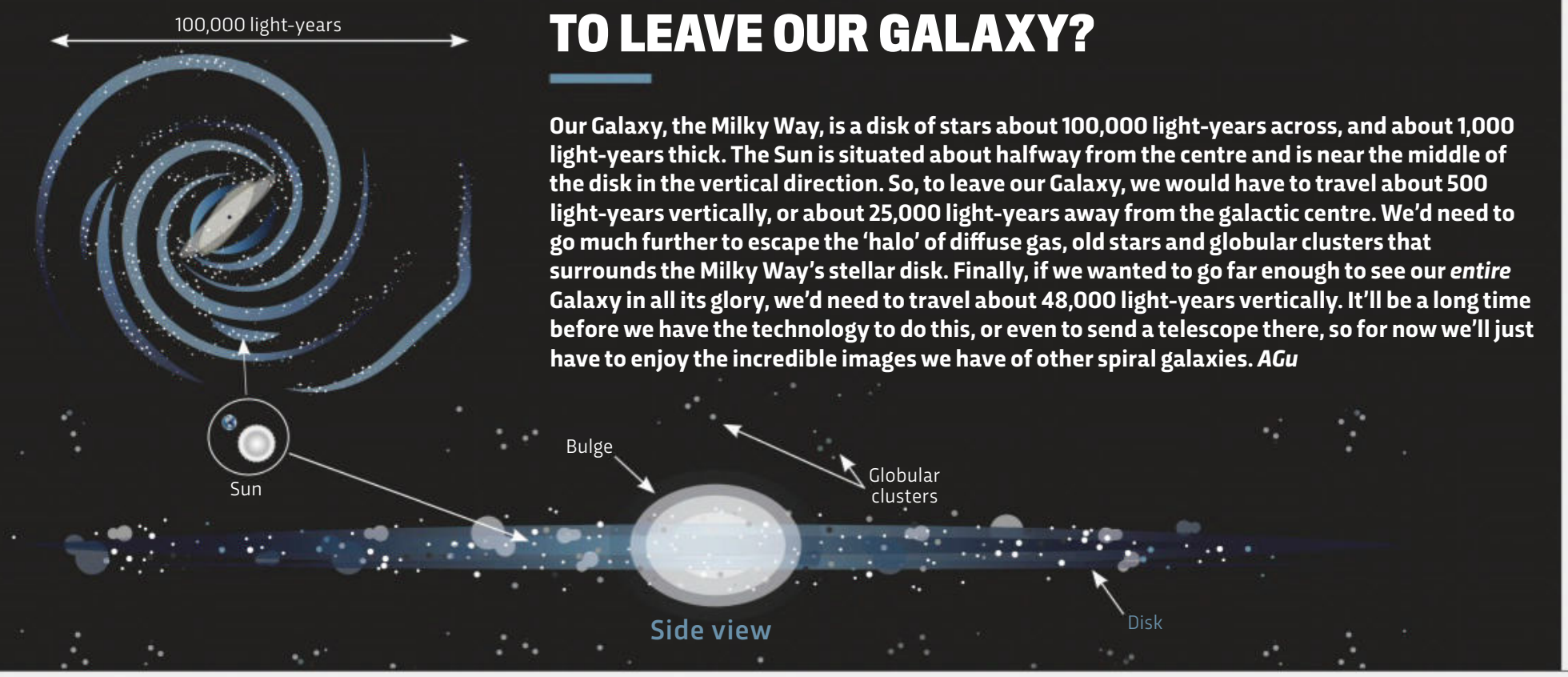
To find the probability of everyone in the group having a unique birthday, multiply all 23 probabilities together, giving 0.493.

So the probability of a shared birthday is 1 - 0.493 = 0.507, or 50.7 per cent. ***RM***

DAVID POLLOCK, CUMBERNAULD

HOW FAR WOULD WE NEED TO TRAVEL TO LEAVE OUR GALAXY?

Our Galaxy, the Milky Way, is a disk of stars about 100,000 light-years across, and about 1,000 light-years thick. The Sun is situated about halfway from the centre and is near the middle of the disk in the vertical direction. So, to leave our Galaxy, we would have to travel about 500 light-years vertically, or about 25,000 light-years away from the galactic centre. We'd need to go much further to escape the 'halo' of diffuse gas, old stars and globular clusters that surrounds the Milky Way's stellar disk. Finally, if we wanted to go far enough to see our *entire* Galaxy in all its glory, we'd need to travel about 48,000 light-years vertically. It'll be a long time before we have the technology to do this, or even to send a telescope there, so for now we'll just have to enjoy the incredible images we have of other spiral galaxies. *AGu*



SAMANTHA BROWN, HITCHIN

WHY DO KIDS LOVE SLIME SO MUCH?

Slime provides a kind of 'sensory play', which helps to engage a kid's senses, stimulate creativity, and can have a calming, in-the-moment effect. It also triggers their curiosity – the gooey texture of slime occupies a weird middle ground between solid and liquid. And, of course, it makes fart noises when they push their fingers into the slime pot... ***LV***

JENNIFER COWSILL, VIA EMAIL

DO WE *REALLY* KNOW WHAT CLIMATE CHANGE WILL DO TO OUR PLANET?

There is no doubt that greenhouse gas emissions caused by humans are changing our climate, resulting in a progressive rise in global average temperatures. The scientific consensus on this is comparable to the scientific consensus that smoking causes lung cancer. Our climate is a hugely intricate system of interlinking processes, so forecasting exactly how this temperature increase will play out across the globe is a complex task. Scientists base their predictions on powerful computer models that combine our understanding of climatic processes with past climate data. Many large-scale trends can now be calculated with a high degree of certainty: for instance, warmer temperatures will cause seawater to expand and glaciers to melt, resulting in higher sea levels and flooding. More localised predictions are often subject to greater uncertainty. ***AFC***

GETTY IMAGES X3 ILLUSTRATION: DAN BRIGHT

OLD WIVES' TALES...

COWS LIE DOWN WHEN IT'S ABOUT TO RAIN

According to a recent survey by the UK Met Office, over 60 per cent of the British public believe that cows lying down is a sure sign of rain. Perhaps the most common theory is that cows are able to sense the approaching rain, either through the increased moisture in the air or the accompanying drop in air pressure, and lie down to keep a patch of dry grass for grazing. Another theory emerged in 2013 when a study in the US showed that cows tend to stand in hot weather, as exposing more skin allows them to cool off more effectively. This led some to hypothesise that the chill in the air that often comes before rain could encourage cows to lie down to conserve heat.

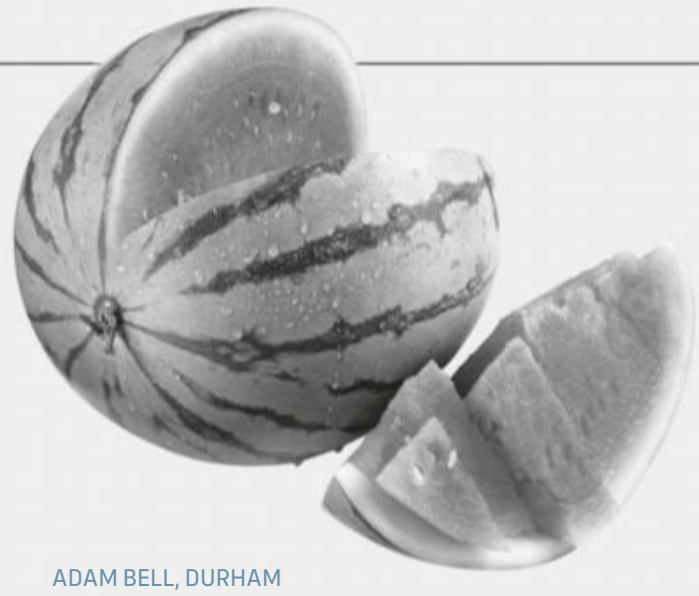
In truth, however, there is no scientific evidence for this piece of weather folklore. The most likely explanation for any correlation between cows' behaviour and the weather is probably simple coincidence – cows spend up to half of their time lying down, either to rest or to chew their cud, so there's a 50:50 chance that they'll be lying down at any given moment, come rain or shine. As herd animals, cows tend to mimic each other's behaviour, upping the odds that you might see a whole herd lying down before a downpour. *AFC*

EXISTENTIAL FEAR OF THE MONTH...

A BUG IS GOING TO CRAWL INTO ONE OF MY ORIFICES AT NIGHT

Let's put your mind to rest about one thing: there is no evidence that we swallow an average of eight spiders a year. Or any other number for that matter. Spiders are generally quite timid creatures and tend to avoid vibrations (from breathing and snoring) and warm, moist environments. Furthermore, this is a completely unverifiable statistic: if you swallowed something whole, in your sleep, how would you ever know?

That's the good news. The bad news is that every orifice other than the mouth is fair game. In 2017, a doctor removed a live cockroach from deep in the sinus cavity of a woman in Chennai, India. Leeches can also work their way into the nose, rectum, urethra and vagina. Endoscopy procedures have also found ants, ladybirds and wasps in the rectum. But the real hotspot for creepy-crawlies is the ears. There are numerous reports of cockroaches, spiders, moths and even an assassin bug being removed from the ears of patients complaining of persistent buzzing sounds. Earwigs probably get their name from the distinctive shape of their hindwings, rather than their preferred habitat. But like many insects, they do occasionally climb into the ear – probably attracted by tasty deposits of earwax. Rest assured, though, having a creepy-crawly enter your body is extremely rare – especially in the UK – and doctors have always been able to remove the beasties without any serious medical complications. *LV*



ADAM BELL, DURHAM

IS THERE REALLY A LINK BETWEEN FOOD AND LIBIDO?

There's no evidence that a single aphrodisiac-packed meal will boost libido. But making sure that you have optimal levels of some key nutrients can help to maintain sex drive. Zinc helps to regulate levels of the hormone testosterone, which can improve sex drive in both men and women. Oysters are the richest dietary source of zinc, but it's also found in many other foods, including meat, tofu and spinach.

Meanwhile, watermelon has a reputation as 'nature's Viagra' because it contains an amino acid called L-citrulline. Once in the body, this converts to L-arginine, which is known to increase blood flow by relaxing blood vessels. A 2011 study at Italy's University of Foggia looked at the effect of citrulline supplements on men with mild erectile dysfunction. After talking the pills, half of the men reported improvements. ***ED***

2

The amount, in metres, that global sea levels could rise by 2100, as estimated by a group of international researchers at the New York City Panel on Climate Change. That's almost twice previous estimates.

ANGIE MUTCH, STONEHAVEN

HOW LONG IS A MOMENT?

The term dates back to at least the 8th Century, when the monk St Bede used it to define a period of 90 seconds. That's probably longer than most people would regard as a moment. But if we just mean the duration of a brief experience, we can at least say how short it can be. In 2014, researchers at MIT showed that the brain can identify images glimpsed for as little as 13 milliseconds. ***RM***

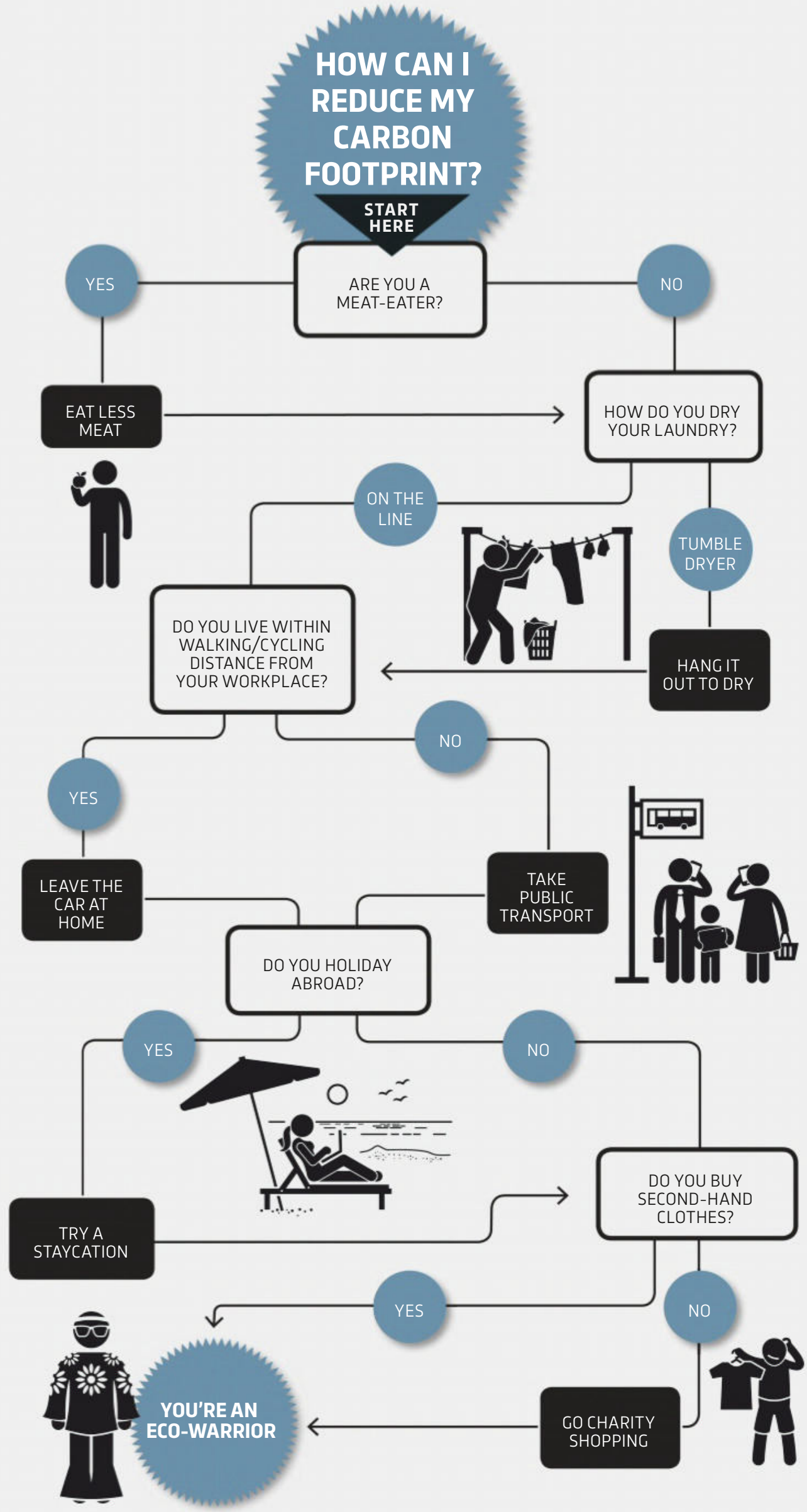
HENRY PARR, FROME

COULD PAINKILLERS ALSO KILL PLEASURE?

A couple of recent studies at the Ohio State University suggested that painkillers can blunt feelings of pleasure as well as pain. The researchers found that one 1,000mg dose of paracetamol could reduce the pleasure experienced from looking at heart-warming pictures, or reading short stories about someone having good luck. It may be that paracetamol affects signalling processes in the brain linked to mood. However, the studies had a limited scope – focusing on students in a lab – making it difficult to equate with real-life settings. ***HG***

GETTY IMAGES ILLUSTRATION: DAN BRIGHT

ALGORITHM YOUR LIFE



EAT LESS MEAT

Lamb and beef have the highest carbon footprint of any food, due largely to the methane that livestock fart and burp into the atmosphere. A 1kg joint of lamb is the equivalent of driving 146km (91 miles) in a car.

HANG IT OUT TO DRY

Putting a single load of laundry in a tumble dryer produces 1.7kg of CO_2. That's almost three times more than the CO_2 produced by washing the clothes.

LEAVE THE CAR AT HOME

Burning a litre of petrol releases 2.4kg of CO_2. If you average eight litres of fuel per 100km (about 35mpg), you could save almost 200g of CO_2 for each kilometre of cycling instead of driving.

TAKE PUBLIC TRANSPORT

A 2005 study at Warwick University found that giving up your car altogether and using public transport will save almost three tonnes of CO_2 per person per year.

TRY A STAYCATION

Flying four people to Mallorca adds two tonnes of CO_2 to the atmosphere, or nine tonnes for Disney World, Florida. If you want to go abroad, consider rail travel. Taking the Channel Tunnel to France instead of flying saves 57kg of CO_2 per passenger per trip.

GO CHARITY SHOPPING

A long-sleeved cotton shirt creates 7kg of CO_2 during manufacture. Using organic cotton can save 1kg by reducing pesticides and fertilisers, but the best way to limit emissions is to buy second-hand.

DEAR DOCTOR...

DELICATE ISSUES DEALT WITH BY *SCIENCE FOCUS* EXPERTS

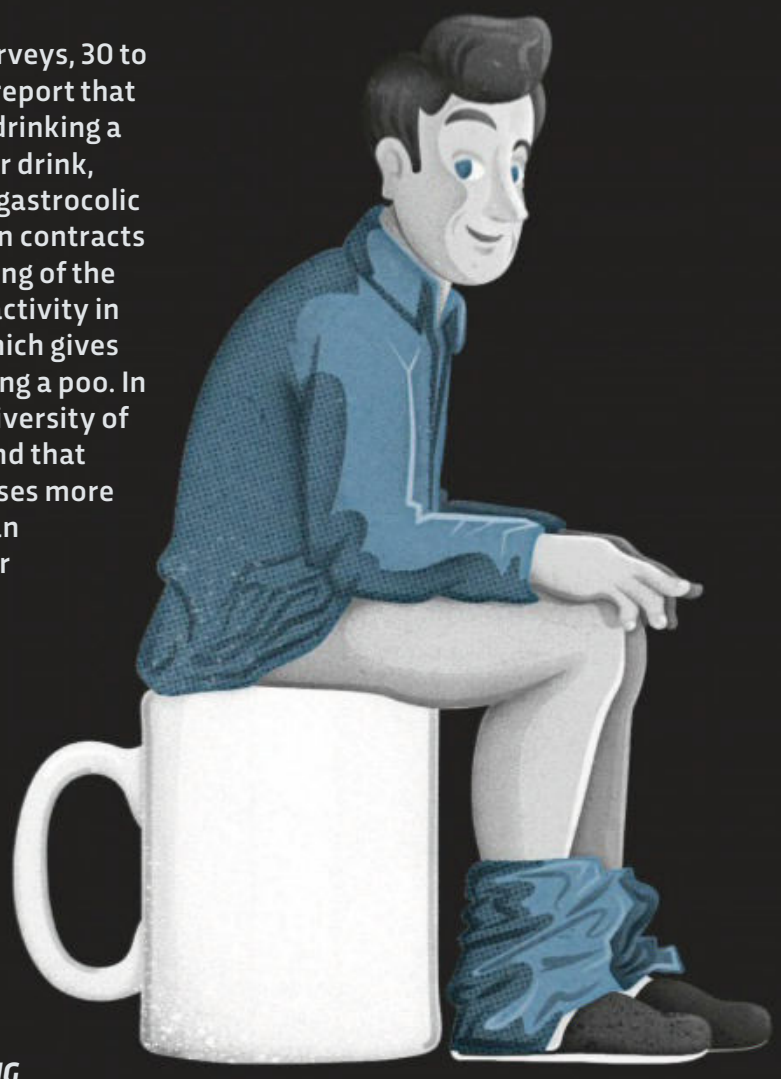
I'M 50 AND I HAVE LOADS OF BAD HABITS. ARE THEY FOREVER ETCHED INTO MY BRAIN?

Our ability to learn new facts and skills continues right through life, into the ninth decade and beyond (should we get that far). At a neural level, recent evidence suggests that 'neurogenesis' (the growth of new nerve cells, or 'neurons') also persists through life, and this may play a role in learning and storing new information.

I mention all this because acquiring new habits, and breaking old ones, is essentially a form of learning. The uplifting implication, then, is that it's definitely worth trying to change your ways. In fact, with the right approach, you still have a very good chance of learning better habits, whether that's eating healthier, doing more exercise, drinking less alcohol, or watching less trash on television (no judgment – we all do!).

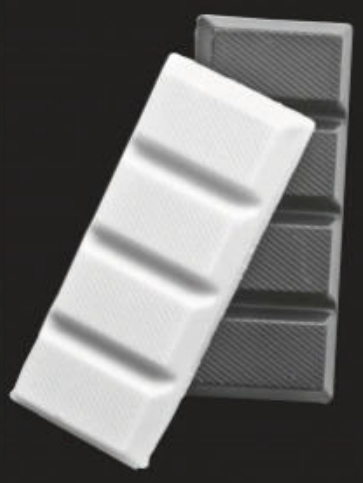
Some basic advice in this regard is to pay attention to the cues or prompts that automatically trigger your bad habits and then practise alternative, preferable behaviours instead – ideally ones that serve a similar need or that you find enjoyable in some way. Alternatively, avoid the triggers of your bad habits in the first place by changing up your routine. Another powerful approach is to establish and rehearse some basic 'if-then' intentions, the more specific the better, such as: "if it is three o'clock, then I will go for a brisk walk". ***CJ***

WHY DOES COFFEE MAKE ME NEED A POO?



You're not alone. In surveys, 30 to 60 per cent of people report that they need a poo after drinking a coffee. Like any food or drink, coffee stimulates the 'gastrocolic reflex', where the colon contracts in response to stretching of the stomach or digestive activity in the small intestine, which gives the sensation of needing a poo. In a 1998 study at the University of Iowa, researchers found that caffeinated coffee causes more colon contractions than decaffeinated coffee or hot water. However, decaffeinated coffee still had more of an effect than water, so caffeine can't be entirely to blame. Other chemicals in coffee that could be stimulating the colon include chlorogenic acid and the snappily named N-alkanoyl-5-hydroxytryptamide. ***HG***

MY GIRLFRIEND JUST BROKE UP WITH ME. WHICH CHOCOLATE IS HEALTHIEST TO BINGE ON: MILK, DARK OR WHITE?



A 100g bar of milk chocolate contains about 530kcal – roughly a quarter of your total recommended calories for the day. If you switched that for a bar of 90 per cent cocoa dark chocolate, you wouldn't save any calories, but dark chocolate does have 75 per cent less sugar than milk chocolate. Binging is not a healthy way to eat, but the lower sugar and more intense taste of dark chocolate makes it less likely that you will feel the same craving to eat it in large quantities. White chocolate is the worst – it has more calories than milk chocolate and more sugar than dark. ***LV***

PETER COLE,
NEW SOUTH WALES

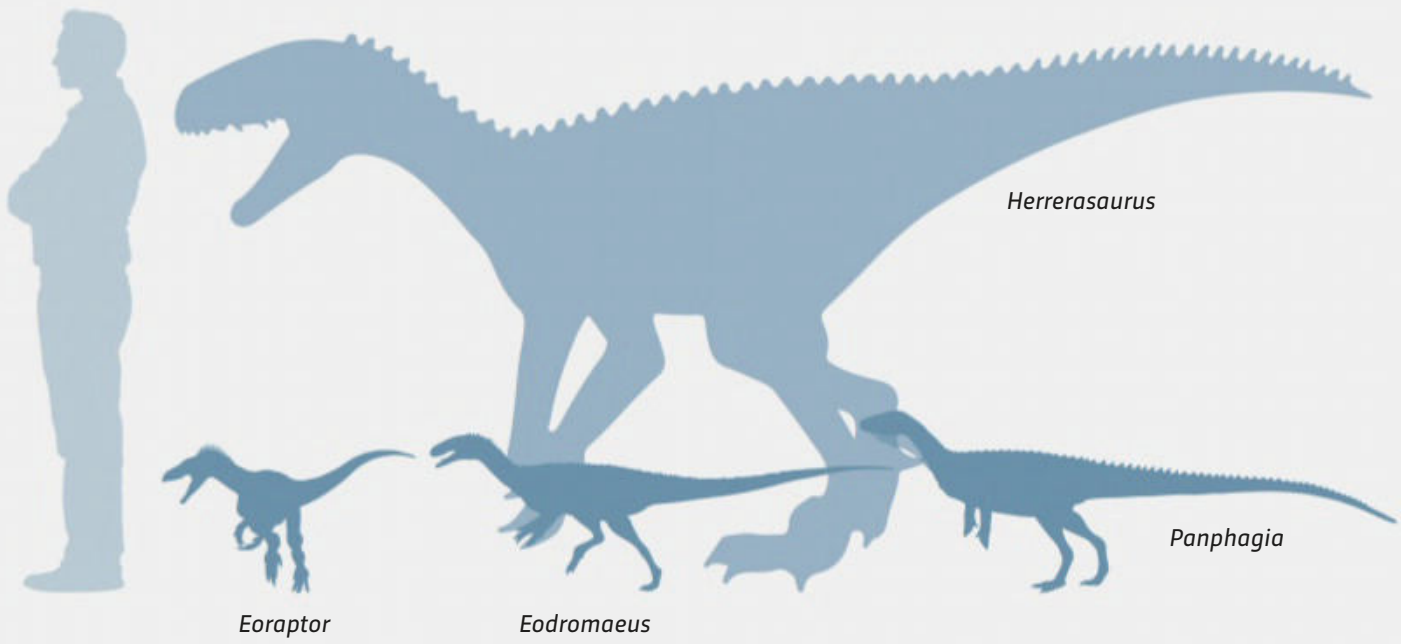
WHAT WOULD BE THE EFFECTS OF LIGHT HAVING MASS?

Light is made up of packets of energy known as photons. So by Einstein's famous equation linking energy and mass, $E = mc^2$, photons do have mass-like properties such as momentum. What they don't seem to have is so-called 'rest mass', the type most of us think of as 'real' mass, measured when an object is stationary relative to us. If they did, the fact that light is an electromagnetic phenomenon means that electric and magnetic forces would get weaker with distance faster than expected. Electromagnetic signals would also travel at different speeds depending on their frequency. However, attempts to detect such effects have so far drawn a blank. The evidence to date suggests that if the photon does have mass, it's less than a billion-billionth that of the electron. ***RM***

HENRY BASS, JERSEY

WHY DO CERTAIN TYPES OF POTATO MAKE BETTER MASH THAN OTHERS?

It's all down to the amount of glue-like starch in your potatoes. Light, fluffy mash contains lower levels of starch. To achieve this, you need potato varieties with naturally *high* starch levels, such as King Edward or Maris Piper. This is because high-starch potatoes have a structure that's easier to mash, so you quickly achieve a smooth consistency, with little starch released from the potato's cells. Avoid low-starch, difficult-to-mash potatoes such as Charlotte and Anya. ***ED***



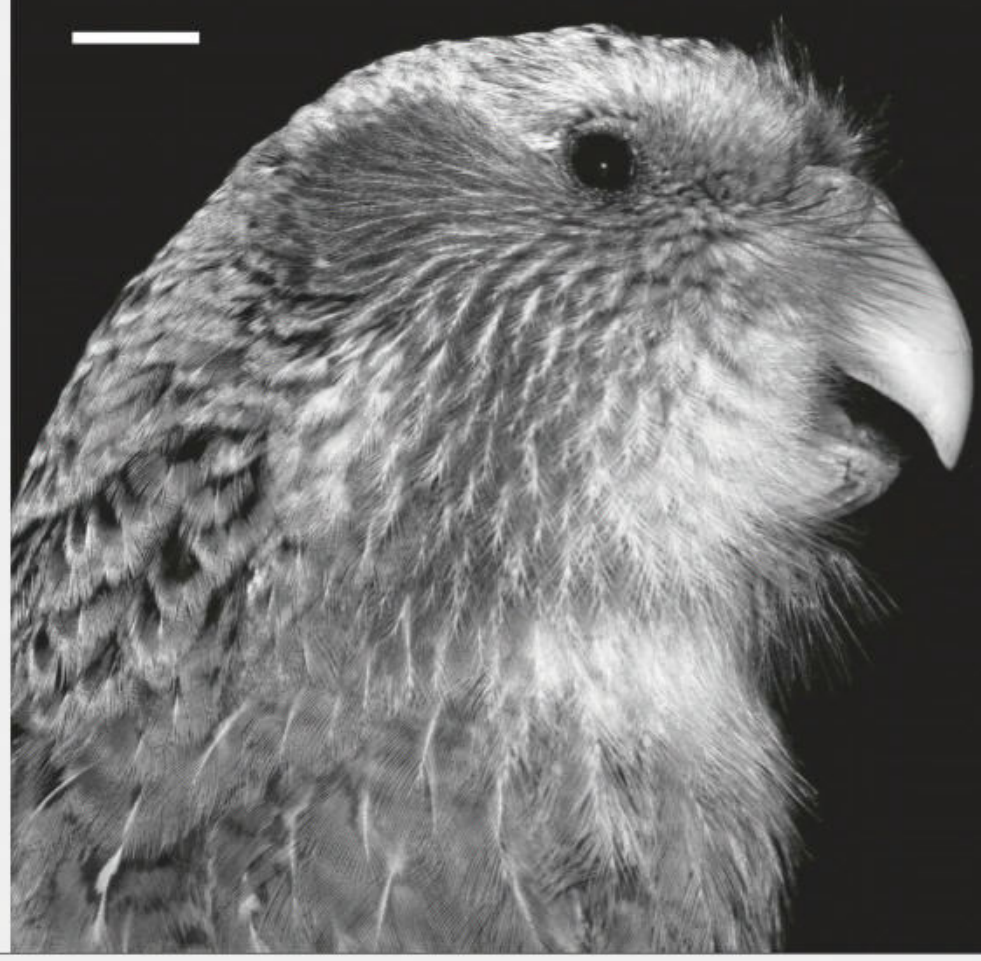
ADAM KING, HUDDERSFIELD

WHAT WAS THE FIRST DINOSAUR?

As palaeontologists uncover more fossils around the world, we keep finding new dinosaurs from the Triassic Period: the first interval of dinosaur history. Currently, the oldest known dinosaurs come from Argentina, and they're about 231 million years old. There are several dinosaurs of this age found together, including the horse-sized meat-eater *Herrerasaurus*, the dog-sized meat-eater *Eodromaeus* (a distant relative of *T. rex*), and several dog-to-bear-sized cousins of the giant long-necked sauropods, including *Panphagia* and *Eoraptor*. The fact that so many dinosaurs, with different diets and sizes, lived at this time tells us that dinosaurs were already diversifying soon after they evolved from other reptiles. But none of these dinosaurs were giants, and none were at the top of the food chain. Those species would come later, during the Jurassic Period. ***SB***

NATURE'S WEIRDEST CREATURES...

THE KAKAPO



Islands that are bereft of predators can work a special kind of evolutionary magic on their birds. Here, flapping flight serves little purpose, and bird species can evolve to lose their flying abilities entirely, gorging on food and developing pot-bellied physiques. Enter, the kakapo: the world's only flightless parrot – and the heaviest, too.

Found only in New Zealand, the bird's name comes from the Maori 'kākāpō', meaning 'night parrot'. Among its nocturnal adaptations are special whisker-like facial feathers for feeling in the dark, a highly developed sense of smell, and a unique musky odour which helps the birds keep track of one another. In the breeding season, males regularly joust for the finest hilltops, digging out a series of bowl-shaped excavations which help to amplify their booming mating calls.

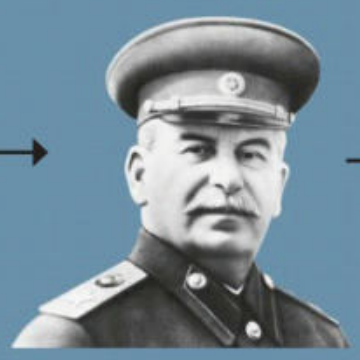
A victim of evolving in a victim-less world, the kakapo has fared badly against a volley of recently introduced predators, including cats, rats and stoats. The bird's main defence technique – simply freezing on the spot – certainly doesn't help its cause. Today, just 147 kakapo remain, but conservation attempts are starting to take effect: this year has been the best breeding season on record. The kakapo's calls have rung through New Zealand's night sky for as many as 30 million years. If we care enough, there may be fight in these old birds yet... *JH*

GETTY IMAGES X3 ILLUSTRATIONS: DAN BRIGHT

WHAT CONNECTS JOHNNY CASH AND SUPERMAN?

1. Long before he became a country music legend, Johnny Cash enlisted in the US Air Force in 1950 at the outbreak of the Korean War. He spent four years stationed in West Germany.

2. He was assigned to the 12th Radio Squadron Mobile, and his keen ear made him one of the best Morse code operators, intercepting coded radio transmissions from the Soviets.



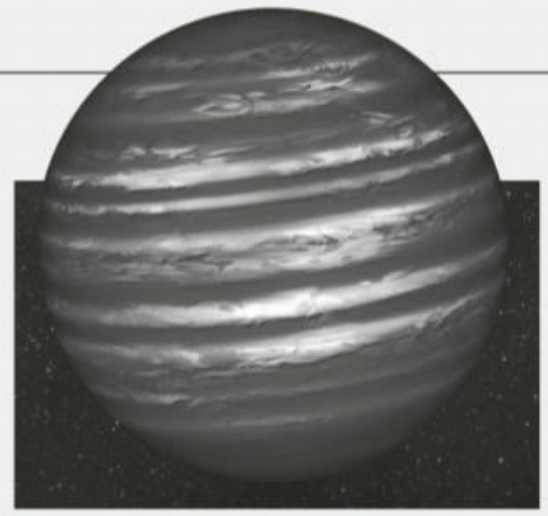
3. On 5 March 1953, he picked up a top secret signal announcing the death of Soviet leader Joseph Stalin. Although he didn't know at the time, he was the first Westerner to receive the news.

4. Stalin's family name was actually Jughashvili. He only adopted the name 'Stalin' when he was in his 30s. It means 'man of steel' in Russian – which is also the nickname of Superman.

FARAZ, LONDON

WHY DO PEOPLE DOODLE?

Surprisingly, doodling while chatting on the phone or sitting through a meeting may be an instinctive way to maintain concentration and retain more information. The idea is that doodling adds just enough effortless stimulation to use up your brain's spare attentional capacity, keeping your mind active and preventing you from spacing out entirely. Recent research at the University of Waterloo, Canada, suggests that an even better strategy than free-form doodling is to create drawings that are relevant to what you're learning. *CJ*



DAVID KELLY, MANCHESTER

HOW WOULD OUR SOLAR SYSTEM BE DIFFERENT IF JUPITER HAD BEEN BIG ENOUGH TO BE A STAR?

If Jupiter had carried on growing, it would eventually have become a star. If this star was a barely luminous 'brown dwarf', it would have only a minor effect on planetary orbits. But if it had become a more massive star, it would probably have prevented planets from forming in stable orbits, and in any case would have greatly increased the amount of radiation their surfaces receive. So the development of life in our Solar System would have been far less likely. ***AGu***

HENRY SYKES, VIA EMAIL

IF THE DINOSAURS DIDN'T GO EXTINCT, COULD THEY HAVE DEVELOPED A CIVILISED SOCIETY?

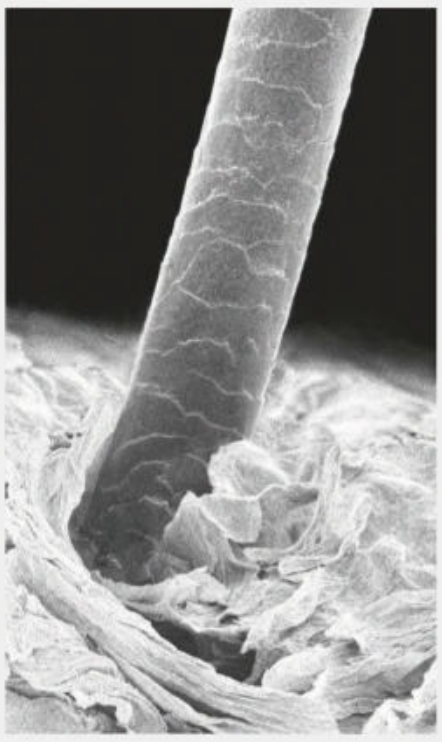
The asteroid strike that killed off all dinosaurs (except for birds) took place 66 million years ago. We know that many species of dinosaur were still thriving at that time. These included small, fast, deadly 'raptors' such as *Velociraptor*, which had big brains and keen senses, and were probably as smart as dogs and cats are today. If they didn't die, but instead kept evolving, they may have developed even bigger brains and keener senses. And given millions of years of evolution, perhaps they would have taken the path of primates, eventually developing tool use, sophisticated communication, and even complex societies. We'll never know, but it's theoretically possible! ***SB***

GETTY IMAGES X4, ALAMY X2, NASA ILLUSTRATIONS: DAN BRIGHT

BRANDON GROOCOCK (AGE 12)

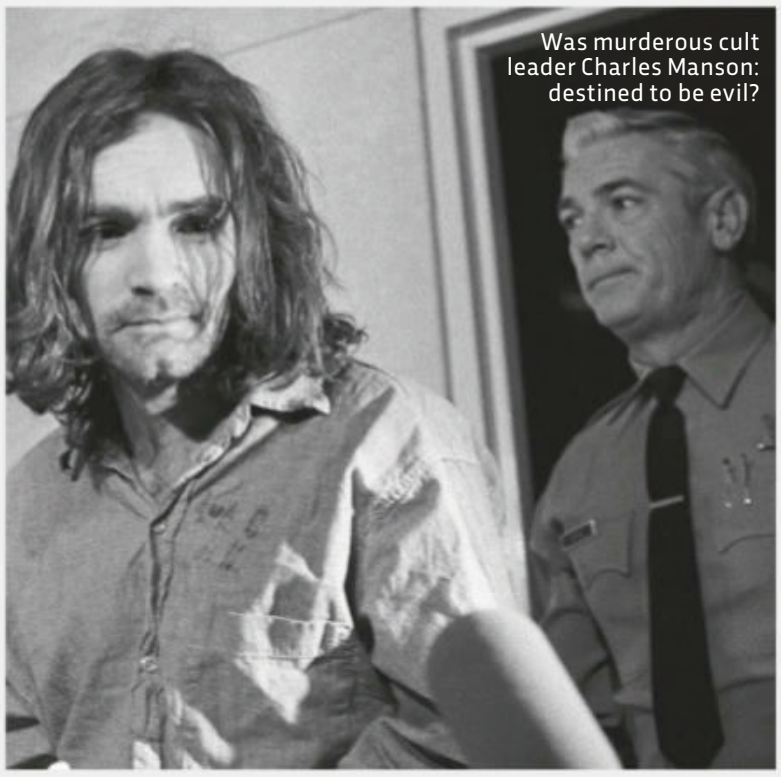
CAN YOU BE ALLERGIC TO HUMAN HAIR?

No. For that matter you can't be allergic to animal hair, either. That's because all mammal hair has the same basic chemical structure: it's almost entirely made of the protein keratin. Our immune systems are exposed to the keratin in our own skin and hair continuously, so we never develop an allergic response to it. Pet allergies are actually a reaction to substances in the animal's skin cells, sweat and saliva (collectively known as dander) that get transferred to the fur during grooming. Animal dander is chemically different enough from our own sweat and saliva that our immune system treats it as foreign. Sometimes this results in an inappropriately strong reaction – an allergy. But humans are genetically so similar that we don't have different dander compounds to each other. A 2005 study at the National Institute of Environmental Medicine in Sweden, however, found that we can trap the dander from our pets in our own hair. So you can suffer an allergic reaction to an animal just by coming into contact with its human owner's hair! ***LV***



BELINDA ANSTEY, DONCASTER

CAN PEOPLE HAVE A GENETIC PREDISPOSITION TOWARDS BEING EVIL?



Was murderous cult leader Charles Manson: destined to be evil?

Many of the sort of people who the media and general public would probably consider 'evil' – such as murderers and other violent offenders who lack remorse – would not be labelled as such by psychologists, who strive for the objectivity of a scientist. Instead, psychologists would describe these immoral, sadistic individuals as high scorers on the personality trait of 'psychopathy', which consists of an interpersonal component (lying and manipulativeness), an emotional component (callousness and lack of emotion), and a behavioural component (violence and criminality). A couple of years ago, researchers at King's College London and Imperial College London conducted a systematic review of 24 studies involving thousands of pairs of twins who had been assessed using measures of psychopathy. The researchers concluded that all three aspects of psychopathy are heritable (passed on through the genes inherited from one's parents) – and that the aspect with the strongest genetic predisposition is the callousness/unemotional element. ***CJ***

QUESTION OF THE MONTH

MAHIKA GAUTAM, LONDON

IF WE'RE EVER ABLE TO MAKE ROBOTS AS INTELLIGENT AS US, WON'T FORCING THEM TO WORK FOR US BE AS BAD AS SLAVERY?

In short: yes. International law on slavery currently applies to humans only, but if robots become as clever as us, then politicians would need to start thinking about tweaking these laws to include robots, too. We'd be foolish not to treat these robots with respect: history shows us that forcing labour from our equals never ends well. Fortunately, the EU is already piloting ethical guidelines for the use of AI software, so it's likely that we would implement legislation to ensure the wellbeing of AIs with human intelligence. If we don't, then they probably will! *PB*

WINNER

Mahika wins a Kodak Printomatic Instant Print Camera, worth £69.99. This fantastic gadget is fun, fast, and easy to use and has a 10-megapixel camera to boot! It's quickly prints smudge-, tear-, and water-resistant 2"x3" sticky-back prints using the innovative ZINK Zero Ink Printing Technology.
bit.ly/2Za1URP

EMAIL YOUR QUESTIONS TO **QUESTIONS@SCIENCEFOCUS.COM**

RADAR

WHAT'S LIGHTING UP OUR ANTENNA THIS MONTH

WELLCOME TRUST, GETTY IMAGES X3, NASA

1. Party time!
The coolest science festival on the planet returns. The likes of Helen Sharman and Jim Al-Khalili join forces with Kraftwerk and New Order to collectively blow your mind.
Bluedot Festival
18–21 July
discoverthebluedot.com

2. Night fever
For adults only, Zoo Nights at London Zoo offers up yummy street food to enjoy, while you take in the wildlife or listen to a range of talks like *The Birds And The Bees Uncut*.
Zoo Nights
Fridays during summer
zsl.org

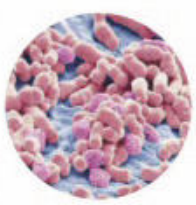
3. Moon party
Moon worshippers will flock to this festival celebrating the Moon landing, set beneath a satellite dish in Cornwall. Includes shows from Orbital and Public Service Broadcasting.
Apollo 50
20 July
apollo50.co.uk

4. A giant leap
Get to know the man who first set foot on the Moon with this award-winning documentary about Neil Armstrong's life, with narration from Harrison Ford.
Armstrong
In cinemas from 12 July
@armstrongdocu

5. Medical marvel
The medical world as you've never seen it before. This year's Wellcome Photography Prize exhibition tackles new categories that shine a light on overlooked stories.
Wellcome Photography Exhibition, 4 July
wellcome.ac.uk

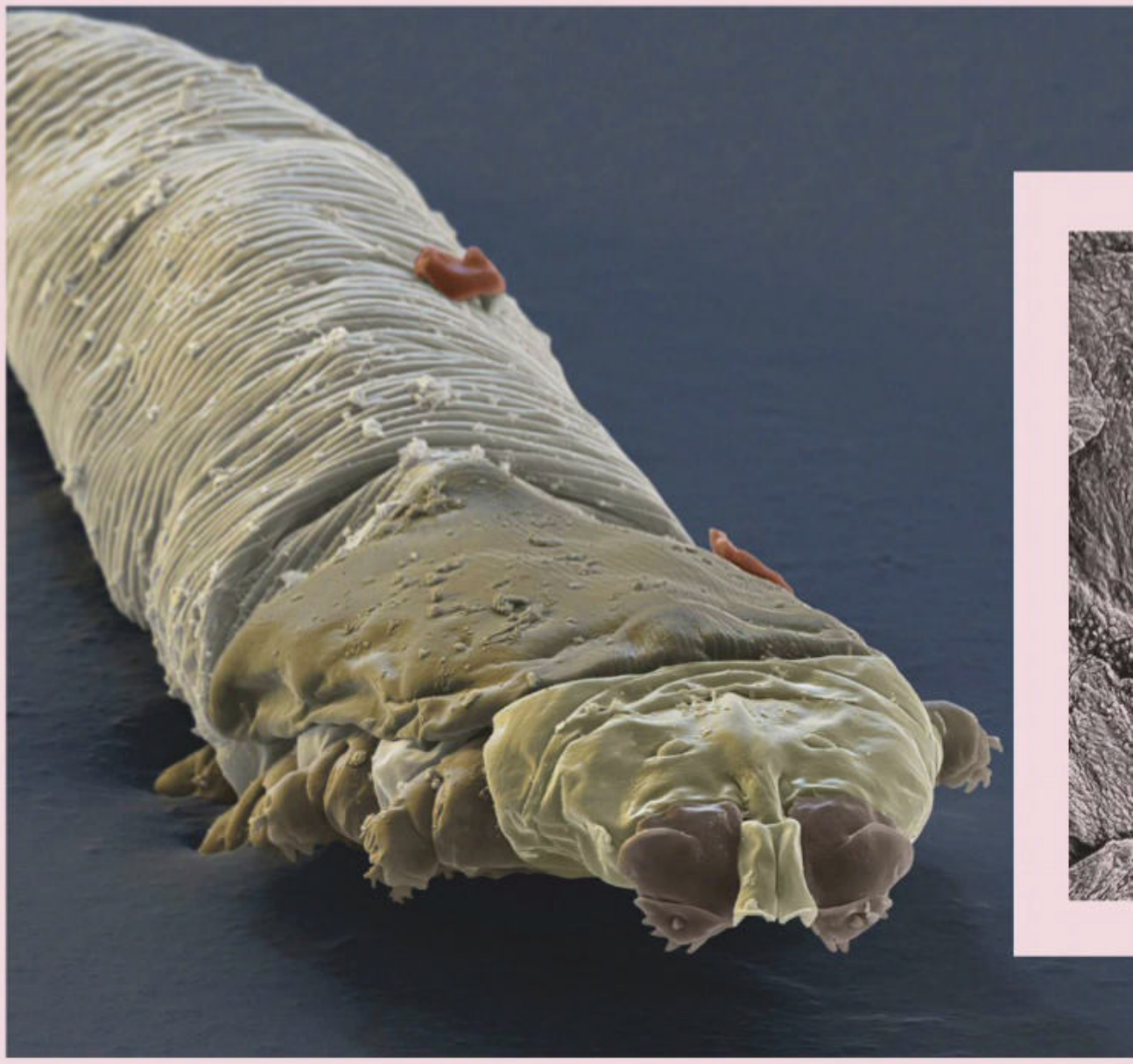
6. Speed racers
In previous years the Goodwood Festival of Speed has brought drone racing, jet packs and autonomous racing cars to the track. We can't wait to see what 2019 brings.
Goodwood Festival of Speed, 4–7 July
goodwood.com

Got an itch? Over 1,000 species of bacteria live on our skin, not to mention fungi, viruses and mites. p90



$3.6bn

Last year, the revenue from sales of VR headsets reached $3.6bn (£2.8bn), 8 per cent more than analysts had predicted. p94



Profile

GETTING UNDER YOUR SKIN

DR MONTY LYMAN, AN EMINENT DERMATOLOGIST, TALKS TO US ABOUT THE IMPORTANCE OF THE BODY'S LARGEST AND MOST VISIBLE ORGAN

WE HAVE BACTERIA LIVING ON OUR SKIN. BUT THAT'S NOT ALL, IS IT?

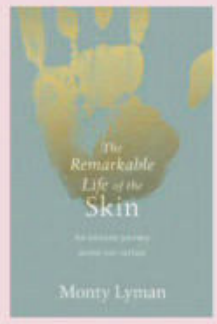
No. We have about 1,000 different types of bacteria that dwell on our skin in different populations and different people. But we also have different types of mites of varying degrees of ugliness, and one of my favourites is called a *Demodex* mite. It is a really horrible-looking mite: it looks like the cross between a worm and a spider. They're present on the skin of quite a lot of people, and they tend to cling to the bottom of hairs, usually around the face. At night, the males swim sluggishly across the surface of your face, searching for a mate. They have quite sad and short lives really. They're good cleaners: they eat dead skin on the surface of our faces. But because these little mites have quite a small digestive tract and they don't have an anus, they keep on hoovering up the skin, and eventually they get more and more bloated until they effectively burst and die.

While they are good at cleaning up the debris on our skin, they actually contain bacteria within their microbiome, and there are some theories that suggest that once these mites die and their gut microbes splurge out onto our skin, we can react quite badly to them. That could be one cause of rosacea, which is a reasonably common skin condition that exhibits itself as redness around the nose and just below the eyes.

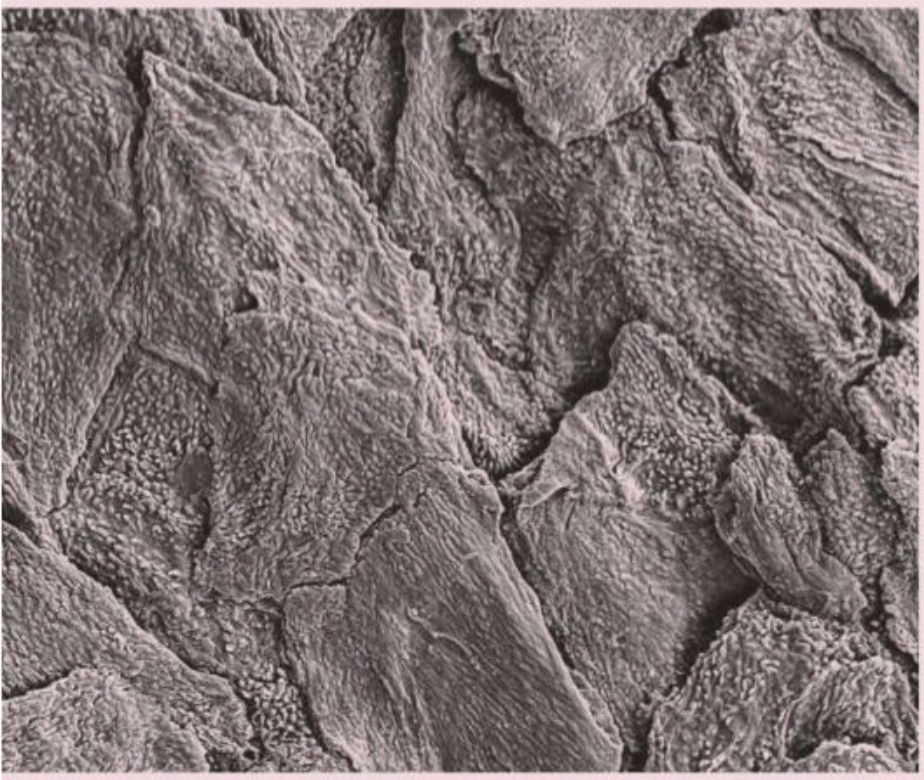
Our discoveries into the skin microbiome are really interesting. A 2017 study found that an underarm bacterial transplant could potentially be the cure for body odour (BO). So, they got a pair of twins, one of whom smelt pretty fresh, the other of whom had quite bad BO, and they hypothesised that it was due to different populations of microbes.

"These little mites keep on hoovering up the skin, and eventually they get more and more bloated until they effectively burst and die"

Our sweat doesn't smell, but it's the bacteria that digest the sweat and create smelly molecules that contribute to BO. So, in this study, they got the twin who didn't smell to refrain from washing for a couple of days, then they swabbed some of his underarm skin for the bacteria. Then, they scrubbed the armpits of the slightly whiffy twin and placed his twin's microbes on his skin, and amazingly, after weeks and weeks, both twins didn't smell



THE REMARKABLE LIFE OF THE SKIN
BY DR MONTY LYMAN
(£20, BANTAM PRESS)



LEFT: ***Demodex*** **mites chomp on your skin flakes then explode**

ABOVE: **The outer layer of the skin, the epidermis, is formed from overlapping layers of skin cells**

at all. That's backed up by studies that show that people of East Asian heritage, particularly Koreans, have the least amount of body odour of any humans, and that's because they, for various different reasons, have very small to negligible populations of the smelly bacteria *Corynebacteria*.

WE OFTEN RISK SKIN DAMAGE WHEN WE TRY AND GET A TAN. IS THERE A SAFE WAY TO GET A 'HEALTHY GLOW'?

A couple of studies have been done over the last 5 or 10 years that have shown that if we eat colourful fruits and vegetables – like carrots, peppers and tomatoes – it gives our skin a yellowish glow.

In one study, men were split into different groups, and one group was encouraged to eat colourful fruit and veg, and then women were asked to judge the attractiveness of the men's faces. They found that the men who had this slight golden glow from eating colourful vegetables as part of a balanced diet were deemed more healthy and attractive than people who didn't eat these, and also people who had a glow from a suntan.

WE TRY TO HAVE BETTER SKIN, BY MOISTURISING, EXFOLIATING, AND TAKING SUPPLEMENTS. IS THIS A MODERN BEHAVIOUR?

Complicated and bizarre skin routines have been around for as long as we have. I've got quite a few favourite beauty routines of people historically. Princess Elizabeth of Austria made a cream from the spermaceti wax from the head of a sperm whale combined with almond oil and some kind of rose water. And then, at night-time, she slapped raw veal on her face and had a made-to-measure leather mask that covered the veal.

There are quite a lot of bizarre and faddish ways of trying to make skin look more attractive that come in and out of fashion. There are some that stand the test of time. So, Queen Cleopatra of Egypt, who was famed for her beautiful skin, had a stable of 700 donkeys who would provide milk in which she would bathe. There is a little bit of science behind that. Some of the acids in milk and citrus fruit, alpha-hydroxy acids, have an exfoliating effect on the skin, making it look more fresh. There's a bit of a debate as to whether that results in an anti-ageing effect, but there are a number of ways in which people try to either slow ageing or make skin more beautiful.

WHAT SIGNS OF SKIN DAMAGE SHOULD I LOOK OUT FOR ON MY SKIN?

It's important to check your skin regularly, getting to know where the moles are and to see whether there are any kind of changes.

The big thing to look out for is potential risk of melanoma, which is one of the three main types of skin cancer. It's the rarest, but it's also the most dangerous. There's an easy way of recognising these on your skin, and it's helpfully categorised into an ABCDE.

A is for asymmetry. Most moles are fairly circular, so look out for ones that appear asymmetrical.

B is for border, so if it also has quite a squiggly, strange border, that's important to note as well.

C is if it has more than one colour in it, so if you have a mole that has one bit that's quite a dark black colour, and one side's a bit red and a bit brown.

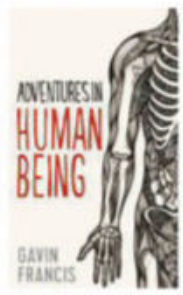
D is diameter. Look out for ones of over six millimetres. I know that's quite hard to measure, but that's roughly the rubber end of a pencil.

And then, importantly, E is both evolution – so how quickly it's been growing on your skin, if you notice it growing over days or weeks – and, most importantly, E is for expert. If you're just unsure about something, or if a mole on your skin looks a bit unusual, go to your local GP and get that seen to.

DR MONTY LYMAN

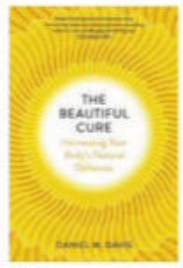
Monty is a dermatologist who has worked in world-leading dermatology laboratories. His book, The Remarkable Life Of The Skin, *(£20, Bantam Press) is out on 11 July.* ***Interviewed by BBC Science Focus online assistant Sara Rigby.***

Author's bookshelf



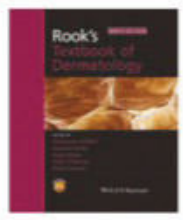
ADVENTURES IN HUMAN BEING
BY GAVIN FRANCIS (£6.99, WELLCOME COLLECTION)

A wonderful – and for me, inspirational – example of how to weave medicine, art and life into a narrative. He eloquently shows how the body is our teacher.



THE BEAUTIFUL CURE: HARNESSING YOUR BODY'S NATURAL DEFENCES
BY DANIEL DAVIS (£9.99, VINTAGE PUBLISHING)

An excellent book on our immune system. His lucid prose lets the science speak for itself, and it beautifully illuminates one of the most exciting, frontiers of modern medicine.



ROOK'S TEXTBOOK ON DERMATOLOGY
(WILEY-BLACKWELL)

The dermatology bible. It comes in four enormous volumes of evidence-based medicine, and it reminds me that I'm standing on the shoulders of giants.

SCIENCE PHOTO LIBRARY X2

Child's play

GET YOUR CHILD LEARNING TO CODE THROUGH PLAY WITH THESE GREAT TOYS AND TOOLS

KANO HARRY POTTER CODING WAND

For the budding wizards out there, this magical kit comes with a programmable wand that will respond to your child's movements in real time. Using the companion app on a phone or tablet, there are over 70 creative challenges and games for them to complete. Then, with a wave, twist or a twirl of the wand, their wizarding world will come to life on the screen in front of them.

£99.99, KANO.ME

SCRATCH ONLINE

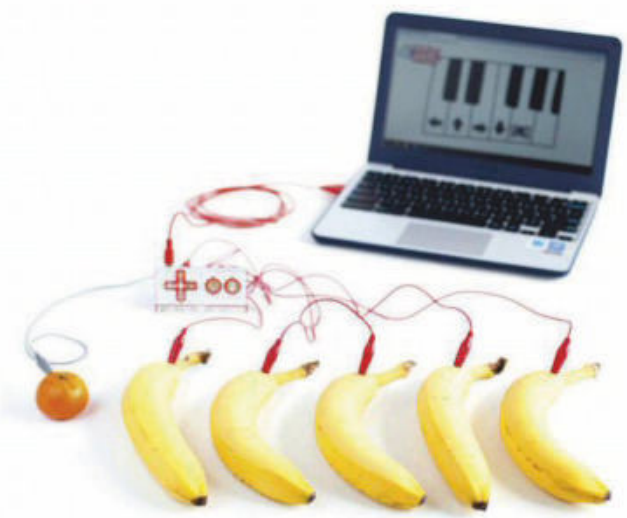
Designed and maintained by Mitch Resnick's Lifelong Kindergarten group (see interview, right) at the MIT Media Lab, Scratch is a programming language and online community where kids can program and share interactive media such as stories, games and animation with people from all over the world. Free to join, it's as easy as dragging and dropping coloured blocks together, and tinkering with the results.

FREE, SCRATCH.MIT.EDU

LEGO MINDSTORMS EV3

Everyone's favourite colourful building blocks are all grown up in Lego Mindstorms, and the EV3 kit contains all the bricks, motors and sensors you'll need to build 17 different robots. The EV3 Programmer app helps kids to program it and bring it all to life, while the Lego Mindstorm community is filled with inspiration for rebuilding and re-programming the robot for almost endless opportunities.

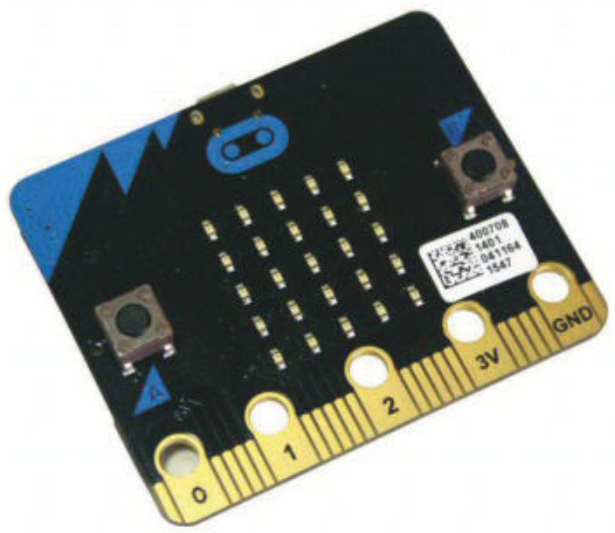
£249.99, LEGO.COM



MAKEY MAKEY

Created by MIT graduates, MaKey MaKey is an invention kit that tricks your computer into thinking that anything is a keyboard. From creating a piano out of bananas to making a game controller from Play-Doh, you just need to plug the MaKey MaKey board into your computer, hook up some alligator clips and you can be creating within minutes, with no extra software required.

$49.95 (£40 APPROX), MAKEYMAKEY.COM



BBC MICRO:BIT

The BBC micro:bit is a handheld, programmable microcomputer that can be used for all sorts of creations, from robots to musical instruments. It has 25 programmable LEDs, two programmable buttons, sensors for light, temperature and motion, and wireless communication via Bluetooth and Wi-Fi. Once you've decided what you want to do with it (there are loads of ideas online), you can start programming in a choice of Javascript or Python. Then wipe it and start all over again.

£14.99, MICROBIT.ORG

Troubleshoot

LEARNING TO CODE

YOU DON'T HAVE TO GET TECHNICAL TO TEACH KIDS HOW TO CODE. IT'S ALL ABOUT LEARNING THROUGH PLAY, SAYS MIT'S PROFESSOR OF LEARNING RESEARCH, MITCH RESNICK

SHOULD CHILDREN LEARN TO CODE AT SCHOOL?

I think they should, but not necessarily for the reasons many people think. People often focus on the future job opportunities that coding could bring, but I make the analogy of learning to write. Everyone learns to write but not everyone becomes a writer or journalist. Coding is much the same. It teaches kids to express themselves creatively, organise their ideas and develop as logical thinkers, which I think is a more important focus.

HOW IMPORTANT IS CREATIVE LEARNING?

I've always been inspired by the way children learn in kindergarten [preschool] whether it's building houses with blocks or making pictures with finger paints, children are playfully creating things, often in collaboration with one another. This helps them to develop as creative thinkers. Unfortunately, as they get older, there are fewer and fewer opportunities to do this in traditional schooling.

In the research group I set up at MIT, the Lifelong Kindergarten group, we want to take the spirit of kindergarten and make it accessible to learners of all ages. We develop technologies and activities to engage kids in creative learning experiences, so they can continue to explore, experiment and express themselves as they grow older.

WAS THAT THE DRIVING FORCE BEHIND SCRATCH?

Absolutely. Scratch is a programming language and online community that we developed to enable kids to program their own interactive stories, games and animations, then share the creations online and collaborate with one another. From the beginning, we did not see Scratch primarily as a way of teaching kids technical skills or how to code we saw it as a way for children to be able to express themselves creatively with new technology.

I think our focus on community and creativity is different from a lot of other approaches, and I think that's what has made it so popular with kids they can make use of Scratch in ways that are meaningful to them. Learning to code is merely a byproduct of that.

HOW HAVE YOU SEEN THE CODING LANDSCAPE CHANGE?

We launched Scratch in 2007, and since then we have been continually amazed and delighted at how it's captured young imaginations, and at the creativity and diversity of the projects that kids create. We are constantly seeing things that we couldn't have imagined.

The difference now is that it's reaching so many more kids from different backgrounds and with different interests, which is great as it means there is larger diversity in what we see. It's appealing to younger kids too. We originally developed Scratch for eight year olds and up, but recently saw scope to launch ScratchJr, to reach ages five to seven.

WHAT ARE SOME OF YOUR COOLEST COLLABORATIONS?

We have collaborated with Lego for many years. I mean, the basic Lego brick was designed to allow kids to create, design and experiment, so

"We want to take the spirit of kindergarten and make it accessible to learners of all ages"

creative learning is really at its core. Recently, we've been working with them to combine the Lego building activities with computational electronics. The result is the new Lego Mindstorms robotics kits, which use Scratch to help you program and control your Lego robotic devices in the physical world.

We also work with the Raspberry Pi Foundation, not only looking to see how Scratch can be the engine for their electronic devices, but also in their outreach efforts like Code Club and CoderDojo. These are free community schemes providing kids with the opportunity to explore new technologies in a creative and social environment.

WHAT ARE THE BIGGEST OBSTACLES IN TEACHING KIDS TO CODE?

I think in general we have to shift the mindset from how people think about education as purely the delivery of information, to seeing learning as an opportunity for kids to explore, experiment and express themselves. So whether it's parents at home or teachers in schools, they need to encourage and empower kids to design and create, and see new technology as a tool in deepening those learning experiences, rather than necessarily something to learn itself.

MITCH RESNICK *@mres*
Mitch is the Lego Papert Professor of Learning Research at MIT Media Lab, author of Lifelong Kindergarten *and founder of Scratch.*
Interview by Verity Burns.

RECOMMENDED

OCULUS QUEST

£399
oculus.com

HIGH-END VR FINALLY GOES WIRELESS, BUT HAS THAT FREEDOM COME AT A COST?

Alexander McNamara
ONLINE EDITOR

Not too long ago we thought we'd be living our best lives through virtual reality (VR) by now. But it hasn't worked out that way. The VR headsets that truly let you leave your fleshy husk behind were expensive and unwieldy, hogging your spare room and demanding powerful gaming computers. Meanwhile an affordable VR experience consisted of glorified goggles clapped on to your smartphone, using whatever grunt your handset could muster to power your experience. A happy medium between cost and power has never been met – the Oculus Quest is out to change this.

WHAT IS IT?

The Quest is the first all-in-one gaming system from Facebook-owned Oculus, so unlike their previous Oculus Rift, and indeed most of their rivals, all the tracking technology is contained within the headset itself. This is hugely significant. Whereas before you had to dot sensors around your room, the internal tracking gives you the freedom to play wherever you have a room with enough space to swing a virtual cat. This means you could play in the garden if you wanted, although my modest living room was adequate.

HOW DOES IT WORK?

Oculus is pretty quiet about what goes on under the hood, but the four cameras sat around the edge of the Quest give you 'six degrees of freedom', so not only can you look around a virtual environment, you can also move through it. Interaction in game is done through the Oculus Touch controllers, which appear as disembodied hands depending on what game you're playing.

To make sure you don't bash into any walls, when you first switch on the Quest, you use the controllers to draw a virtual boundary around you, known as a 'Guardian'. I created a play area that managed to skirt around the sofa, TV and various cupboards. While you are playing a game or a VR experience, a superficial wall is overlaid on top of the game as visual warning that you're approaching the edge of your play area. I felt confident enough to roam about without knocking our wedding photos off the mantlepiece. The only thing that felt the full force of my flailing hand was the ceiling light shade as I attempted a smash during a particularly enthusiastic game of *Racket Fury Table Tennis VR*.

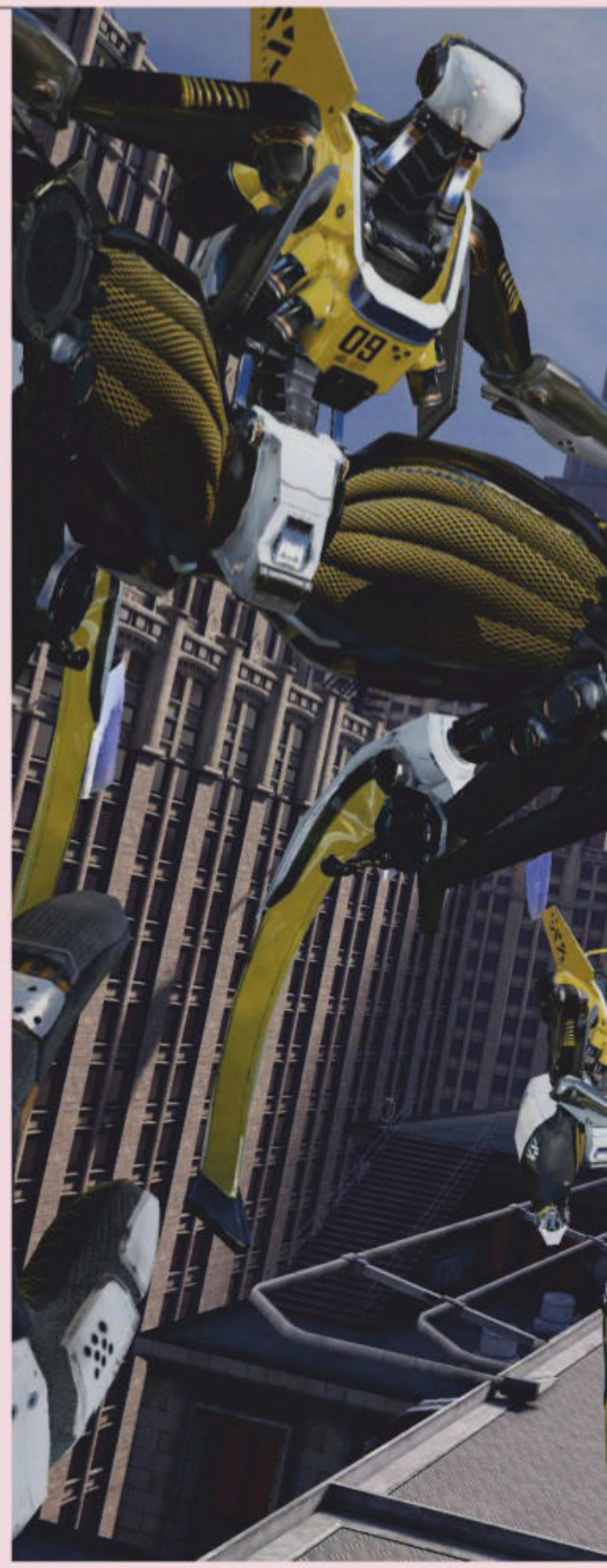
If you're after a more sedate experience, you can also set up a guardian around you from a sitting position.

WHAT'S IT LIKE TO PLAY?

Having the freedom to move around virtual environments untethered immediately raises the bar when it comes to VR, and it's obvious from the moment you first put the headset on that this far surpasses anything you get from a smartphone. But unless the device is comfortable to wear, you're unlikely to stick with it for long.

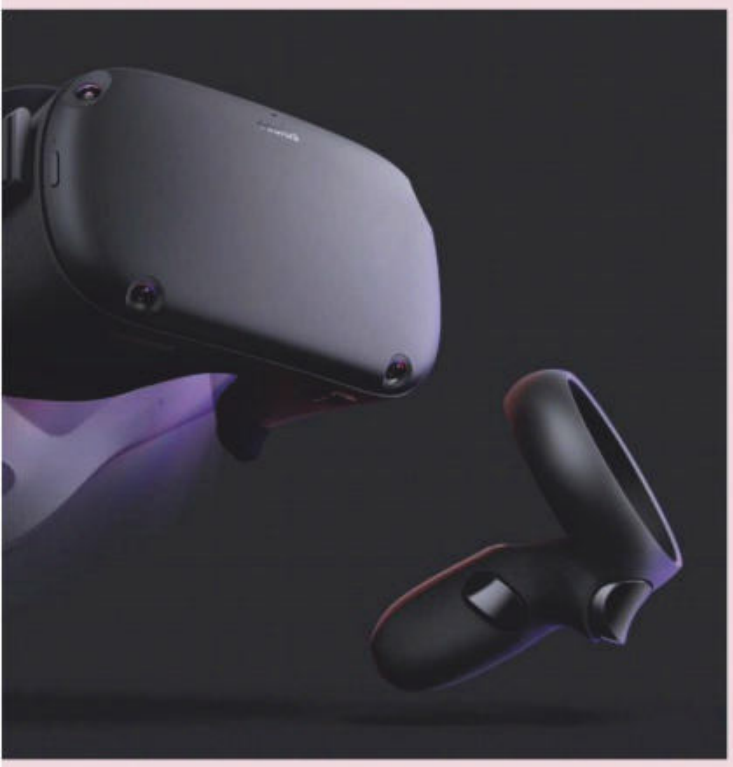
Fortunately, the Oculus Quest ticks almost all the boxes for comfort. The fabric lining that covers the inside of the headset is super soft, and the adjustable strap slots snugly around your head keeping everything in place, largely avoiding the distinctive goggle marks you get around your eyes with most other headsets.

One of the chief concerns people have with VR is that it makes them feel sick, which happens when there is a mismatch between what you see and what your body experiences, so any lag in the system can make you go green pretty quickly. The good news here is that despite bobbing my head over and around



LEFT: **The Oculus Touch controllers give you a pair of in-game disembodied hands, as seen here in *Robo Recall***

BELOW LEFT: **Oculus Quest doesn't need a high-powered PC to operate**



objects in *Shadow Point*, or wafting a lightsaber around in *Beat Saber*, I never felt that there was any delay when moving my head. There is the inevitable wooziness you get when you move around in VR and not real life (similar to stepping onto a stopped escalator), but this is something you get used to over time.

It's not perfect, though. Given all the computing power is boxed up in front of your eyes, it is a little heavy and you can definitely feel the heat coming out of it. But I was still able to have a long, two-hour session of gaming before I had to call it quits, and a low battery warning had a part to play in stopping. There was also a small amount of light that leaked in from over my nose, but unless you're actively looking down with your eyes rather than your head, you can easily avoid this being a problem.

HOW DOES IT COMPARE TO OTHER VR SYSTEMS?

Being an all in one system, there are compromises. The graphics aren't as smooth or sharp as the computer powered headsets, due to the slower refresh rate and lower resolution. Still, when you're immersed in VR the effect is barely noticeable. Factor in the ease of use and cost (the standalone Oculus Rift S and a supporting PC will set you back at least £1,000), and the trade off is well worth it. It's also powered by a Qualcomm Snapdragon 835 processor, the same as the one in the two year old Samsung Galaxy S8, so you can't play some of the more graphically intensive games you find on the likes of the HTC Vive or PlayStation VR.

SO WHAT'S THE VERDICT?

Virtual reality is coming of age, and now it's possible to go deep into VR without being tied down to an expensive computer or an underpowered experience. There are enough quality games to get you started (50 at launch), and there is no reason why the Oculus Quest can't start to make a decent dent in the gaming market as this number grows.

At £399, the cost might still be too much for some casual gamers, but the Oculus Quest experience took me way beyond anything I've seen before using a smartphone and has made me seriously consider my PlayStation's prized spot in the living room.

THREE GAMES TO PLAY

Apollo 11 Quest (£7.99)
Take a small step into Neil Armstrong's boots with this cinematic experience following the critical moments of the Moon landing.

Star Wars: Vader Immortal (£7.99)
Release your inner Jedi and take on sci-fi's biggest villain as you blast your way out of trouble on an Empire starship.

Racket Fury Table Tennis VR (£14.99)
If you haven't got space for a ping pong table, a virtual one will do nicely, especially if it's got robot opponents.

DISCOVER MORE

SQUEEZE EXTRA JUICE OUT OF THE TOPICS IN THIS ISSUE OF *BBC SCIENCE FOCUS* WITH THESE BOOKS, WEBSITES AND SHOWS

Eye opener *p8*

INSIDE A FUSION DEVICE

Take a closer look at the Wendelstein 7-X nuclear fusion facility with these interactive 360° panoramas. As well as showing you inside the guts of a reactor, there are videos of the team explaining their work.
bit.ly/fusion_reactor

Discoveries (Horizons) *p26*

WILDING: THE RETURN OF NATURE TO A BRITISH FARM

BY ISABELLA TREE
(£9.99, PAN MACMILLAN)

In this wonderful book, Isabella Tree tells the story of the Knepp Estate. She and her husband turn over farmland to wild pigs, deer and cattle in the hope of providing a little oasis for wildlife in West Sussex. It's a great memoir that opened our eyes to just how scarce wildlife habitats are in the UK.

Reality check *p32*

IS BODY POSITIVITY THE ANSWER TO BODY IMAGE ISSUES?

Check out our full podcast with Dr Phillippa Diedrichs, a psychologist at the University of the West of England, who investigates how to encourage people to engender a positive body image.
sciencefocus.com/science-focus-podcast/

MENTAL HEALTH

From anxiety to depression to body image, check out an incredible array of stories around mental health and the science behind it over at the BBC's mental health page.
bit.ly/bbc_mental_health

CHERNOBYL'S WILDLIFE

Watch videos from camera traps set in the Chernobyl Exclusion Zone. Spy on lynxes, wolves and deer as they travel through one of the wildest places on Earth.
bit.ly/chernobyl_webcam

The technicolour dinosaurs *p48*

THE COLOUR OF DINOSAURS

In this video from BBC Four's *How To Build A Dinosaur*, Prof Mike Benton explains how scientists are able to reconstruct dinosaur colour from fossilised feathers
bit.ly/build_dinos

WEIRD DINOSAURS: THE STRANGE NEW FOSSILS CHALLENGING EVERYTHING WE THOUGHT WE KNEW

BY JOHN PICKRELL
(£24, COLUMBIA UNIVERSITY PRESS)

John, the author of our feature, met the dinosaur hunters right at the cutting-edge of palaeontology for his latest book. It's an impassioned read, that provides a vivid window into the golden era of fossil discovery and conveys just how fast our understanding of the distant past is changing.

Toxic masculinity *p58*

WHY FATHERHOOD IS A GAMECHANGER FOR GENDER EQUITY

In this TEDx talk, Gary Barker explains why he thinks fatherhood and male caregiving can play an important role in ending violence.
bit.ly/TEDx_fatherhood

FOR MORE, FOLLOW US

@SCIENCEFOCUS

Meet the human hibernators *p66*

LOST AND FOUND: WHY LOSING OUR MEMORIES DOESN'T MEAN LOSING OURSELVES

BY DR JULES MONTAGUE
(£20, SCEPTRE)

This fascinating book by Dr Jules Montague, author of our piece on Kleine-Levin Syndrome, asks what happens to a person's identity when they experience a brain disorder. This is a must-read for anyone wanting to understand the relationship between our brain and who we are, and in particular, what happens when injury or illness chips away at our mental faculties.

Alien atmospheres *p72*

EXO-CLIMATOLOGY RESEARCH GROUP

Dive into the work of the exo-climatology group at the University of Exeter, who are using computer models to simulate the air on planets in other solar systems.
exoclimatology.com

EXOPLANET VR TOUR

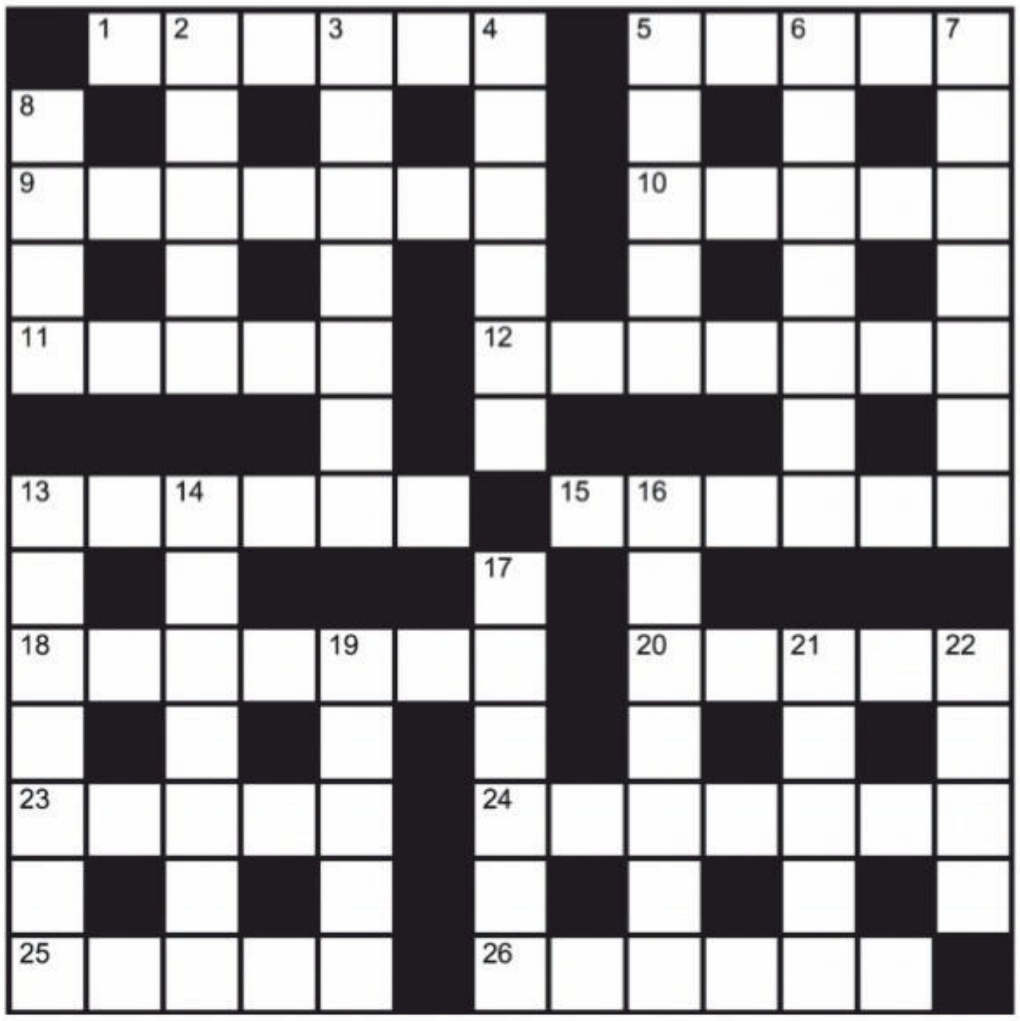
Take a virtual tour (or just enjoy it in 360° on YouTube) of six exoplanets. This visualisation made by science museum We The Curious will submerge you in the waves of Kepler-62e and stand you on the lava fields of 55 Canceri e.
bit.ly/exoplanet_fun

HORIZON: OCEANS OF THE SOLAR SYSTEM

Closer to home, the *Horizon* team meet the scientists studying oceans on our neighbouring planets in the hope of detecting alien life.
bit.ly/horizonplanets

CROSSWORD

GIVE YOUR BRAIN A WORKOUT



ACROSS

1 Announced name of composer (6)
5 Difficult to follow cold vegetable (5)
9 Fair about container being Egyptian for one (7)
10 Wrong time to get right hat (5)
11 Heard note from singer (5)
12 Sea creature finds work after a month (7)
13 Continue the summary (6)
15 Chicken pursues quiet musician (6)
18 Choose unending fool over artist (7)
20 Firm, repeating a bedtime order (5)
23 Pope from the city (5)
24 Last word in bargain report (7)
25 Warden misses first appearance (5)
26 Register for a large drink (6)

DOWN

2 Borderless Italian island arranged no protection (5)
3 Style with strange propriety (7)
4 Behold new professor gets capital (6)
5 Arrive on time to see celestial object (5)
6 Car spy organised late examination (7)
7 Furniture item useful to an actor (7)
8 Loud performance, it's true (4)
13 Disturb river – put liquid on another (7)
14 Dismiss objection to early instrument (7)
16 Stole away with keys and some sugar (7)
17 Bishop should be bribed (6)
19 Bright son, amusing, having lost head (5)
21 Indifferent about British computer language (5)
22 Tree expert, orchard's second (4)

BOEING

ANSWERS

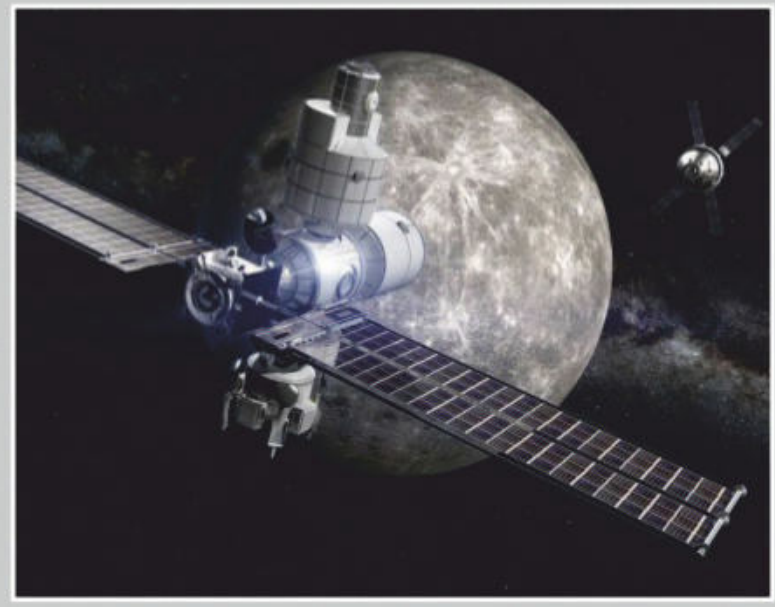
For the answers, visit **bit.ly/BBCFocusCW**
Please be aware the website address is case-sensitive.

NEXT ISSUE

COVER STORY

SPACE EXPLORATION: THE NEXT 50 YEARS

Fifty years after Apollo, we reveal what upcoming space missions will look like.



PLUS

MOON CONSPIRACY

Some people think that the Apollo Moon landings were faked. Read our handy guide and you'll be ready to debunk their arguments.

JAMES LOVELOCK INTERVIEW

On the eve of his 100th birdthday, we talk to James Lovelock, creator of Gaia Theory, about the Novacene Period and the coming age of hyperintelligence.

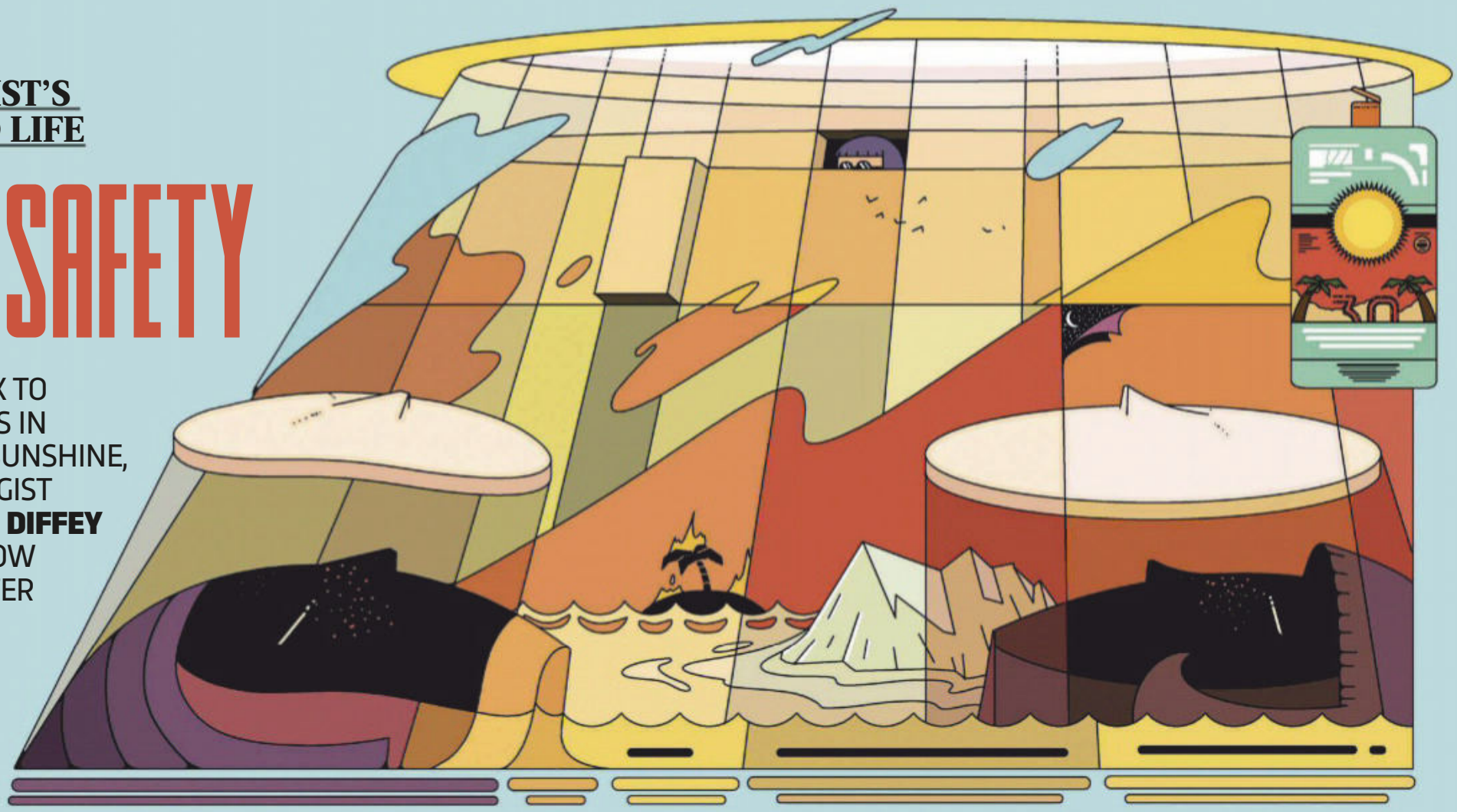
ON SALE 17 JULY

SF

A SCIENTIST'S GUIDE TO LIFE

SUN SAFETY

AS WE FLOCK TO THE BEACHES IN SEARCH OF SUNSHINE, DERMATOLOGIST **PROF BRIAN DIFFEY** EXPLAINS HOW TO LOOK AFTER YOUR SKIN



SHOULD I STILL USE SUNSCREEN IF I'M IN THE SHADE?

Potentially, yes. Ultraviolet (UV) light is scattered in the atmosphere. When you're in the open, half the UV rays reaching your skin come directly from the sun. The rest is scattered UV that comes from the sky. If you're in shade, you're still exposed to this scattered UV.

WHY DO I BURN SO EASILY AT THE SEASIDE?

Lots of people think it's because the UV is reflected off the water, but that's not true. Very little comes from the sea. The reason is that there's no shade. You have this whole wide sky around you, so you're receiving the UV from the sun, and all the scattered UV from the sky.

HOW SHOULD I APPLY SUNSCREEN?

Sunscreen works by forming a barrier between the sun's rays and the living cells of your skin. Don't rub it in vigorously because that forces it deeper into the skin, and you end up exposing the vulnerable cells near the surface. You want it to rest on the surface of your skin, so spread it smoothly, then let it dry.

HOW MUCH SHOULD I APPLY?

When manufacturers test the SPF (sun protection factor) of their products, there's an internationally agreed thickness of 2mg per centimetre of skin, but my research shows that people tend to put on roughly half this amount because otherwise it feels too thick. So, if you use an SPF30 sunscreen, you end up with a delivered SPF of 10 to 15. The way round this is to put on a layer of sunscreen the way you like it, let it dry, then apply a second layer around 30 minutes later.

SHOULD I APPLY SUNSCREEN EVERY DAY?

Some people say you should, but there's no need. In the winter, the sun is weak, we stay inside more and we're covered up. In the summer, if you're just nipping outside for half an hour, it's okay too. Being overly concerned is detrimental. We all need a bit of sunshine to make vitamin D.

ARE EXPENSIVE SUNSCREENS BETTER THAN BUDGET ONES?

Not necessarily. You're not paying for better protection. You're paying for aesthetics. These products might smell or feel better, but it's all down to individual preference. I go for mid-range products made by reputable manufacturers.

WHAT KEY INGREDIENTS SHOULD I BE LOOKING FOR?

A good sunscreen contains different ingredients, each designed to focus on a particular range of UV wavelengths. Don't worry about the specific ingredients. Instead, turn the bottle over and look at the star rating. This is something I invented. Four or five stars means you have protection against the whole UV spectrum.

IS HIGH SPF BETTER THAN LOW SPF?

Yes, in principle, but some products with higher SPFs are difficult to spread. They feel a bit claggy, so people tend to put less on. It's important to balance the aesthetic qualities of sunscreen with the concentration of its ingredients. **SF**

PROF BRIAN DIFFEY

Brian is an emeritus professor of photobiology at Newcastle University, and a member of the British Association of Dermatologists.

Interviewed by Dr Helen Pilcher.

NEED TO KNOW...

1

Even if you're sitting in the shade, you should still apply sunscreen.

2

Expensive sunscreen doesn't equal better protection.

3

Don't rub it in. You need a layer of sun protection *on top* of your skin

ILLUSTRATION: ORI TOOR

Seeing is believing...

visionace®

with **vitamins A, B2** & **Zinc**
which help to maintain

normal vision

Visionace® is based on extensive research and has been expertly formulated with over 20 nutrients including Bilberry and Lutein, with specific nutrients to help support your vision.

ORIGINAL PLUS OMEGA-3 MAX

Britain's No.1 Vitamin Company*

*Nielsen GB ScanTrack Total Coverage Unit Sales 52 w/e 1 December 2018.

From Boots, Superdrug, Holland & Barrett, supermarkets, chemists, health stores
www.visionace.com

OVER 45 YEARS VITABIOTICS

Made in Britain

THE QUEEN'S AWARDS FOR ENTERPRISE: INNOVATION 2018

VITABIOTICS
SCIENCE OF HEALTHY LIVING

2019-01-03 ADVISCONP E

FUJIFILM

X

MASTERS OF DESIGN

Over 80 years of experience in photography goes into every camera we make, so you can be sure they always handle perfectly

FUJIFILM-X.COM